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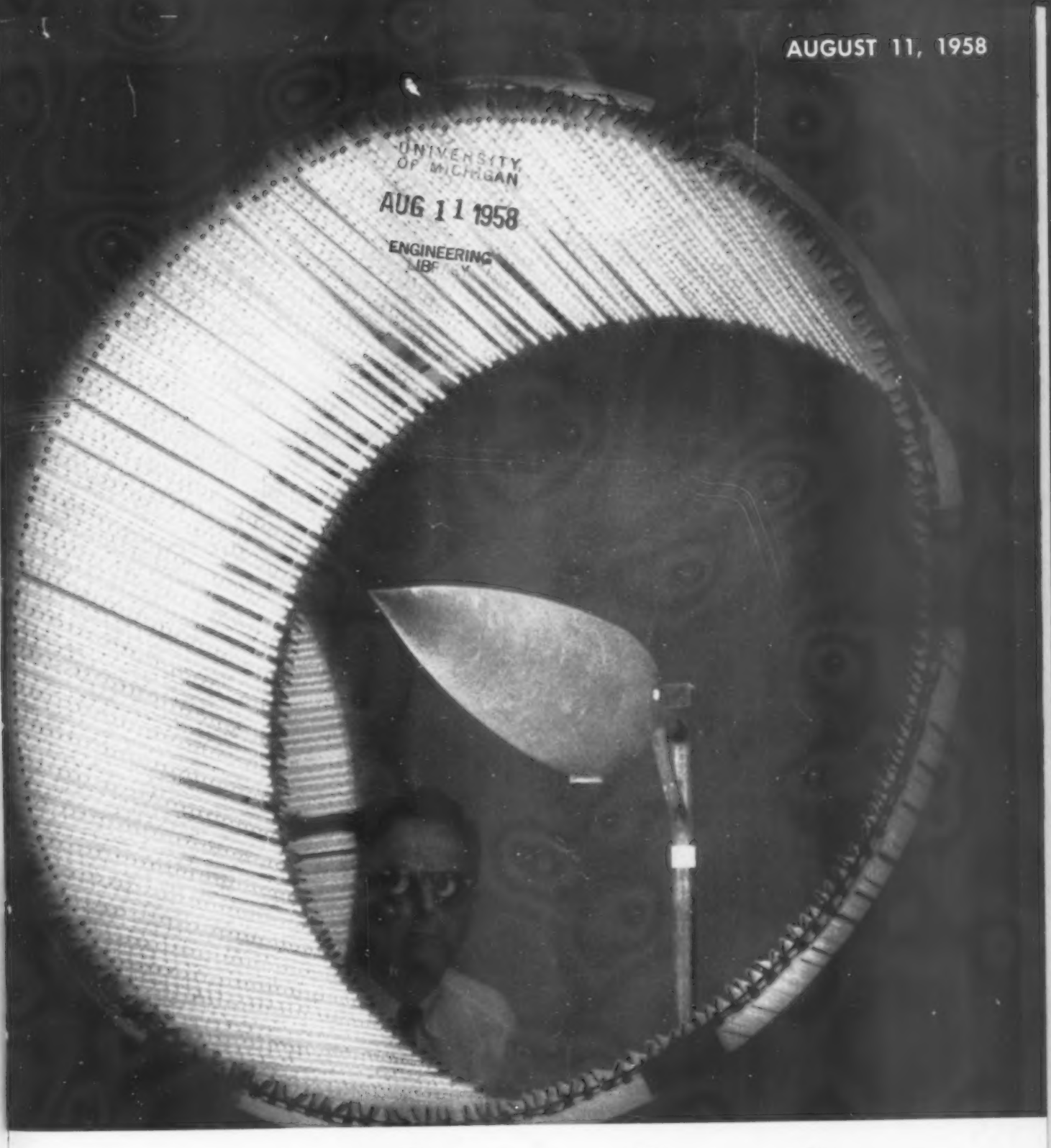

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Engineering and Electronics Edition

AN AMERICAN AVIATION PUBLICATION

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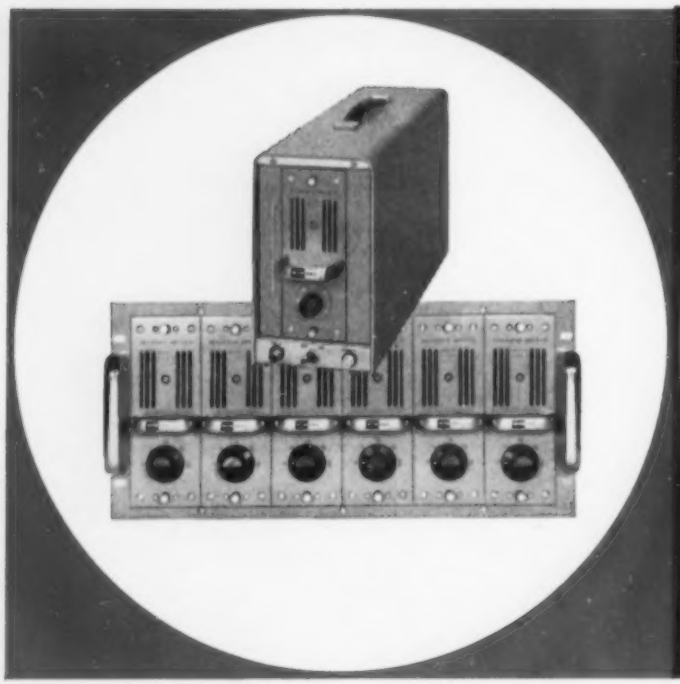

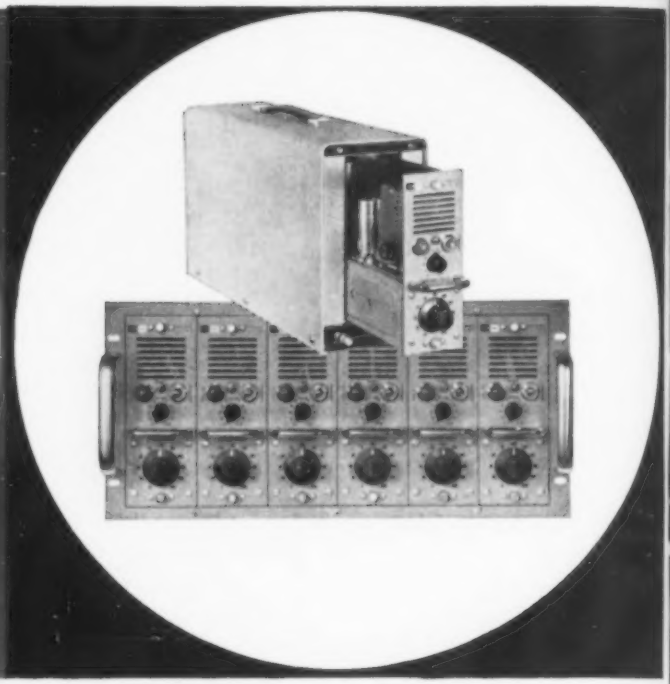

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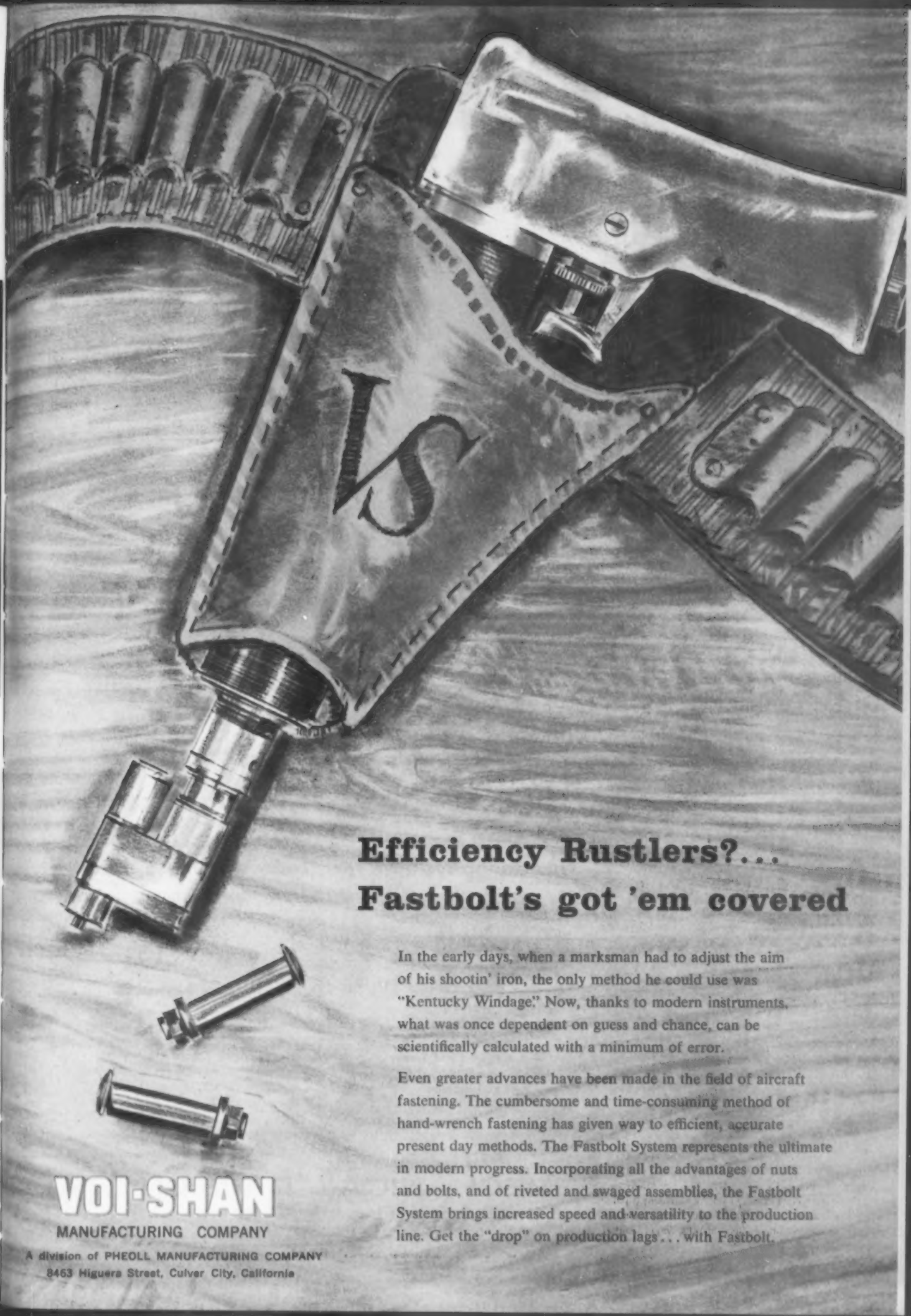

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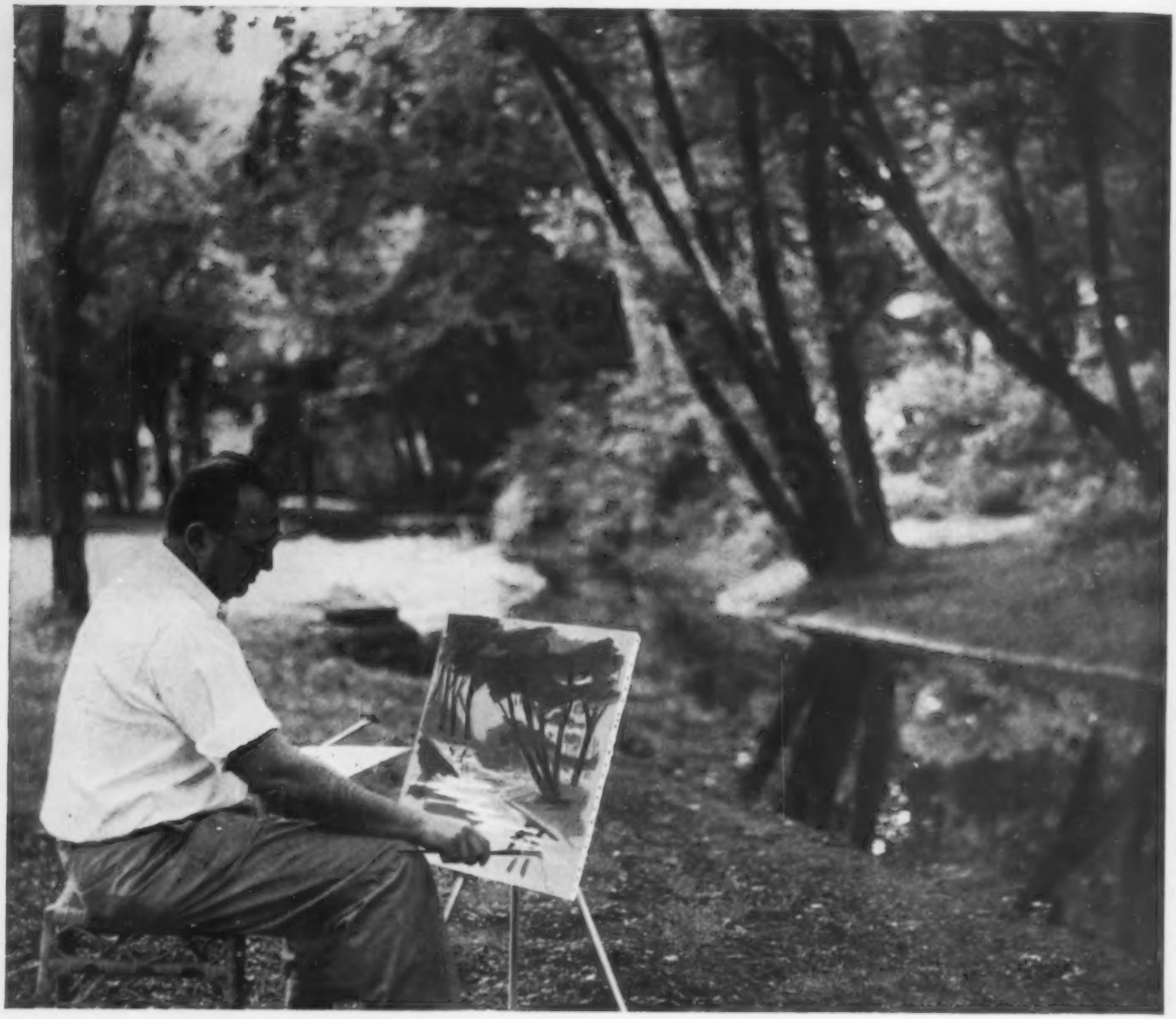

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news

$6.6 Billion For Missiles This Year
by Seabrook Hull 12

Air Force Re-establishes Space Office 14

U.S. Not Racing Anyone To Space 16

Firing Date Dubious For Lunar Probe
by Donald E. Perry 17

features

m/r special report:

Solid Fuels Vie For Propellant Lead
by Alfred J. Zaehringer 28

Recorder Offers Speedy Data Processing
by Richard Van Osten 38

Shock Tests Vital as Birds Get Bigger
by Raymond M. Nolan 40

Astrodyne Shifts to Cast Grains 45

Why Not A Logical Approach to Space Flight?
by W. O. Davis 49

Soviets Discuss Satellite Crew Recovery
by Frank G. McGuire 51

columns

World Astronautics 55

Keeping Track 59

Space Age 74

Missile Business 79

departments

Editorial 7

Industry Countdown 9

Washington Countdown 11

Book Reviews 56

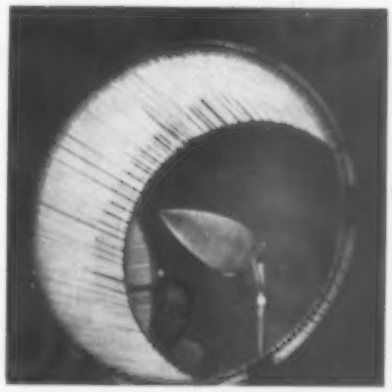
When and Where 57

Missile Electronics News 60

New Missile Products 66

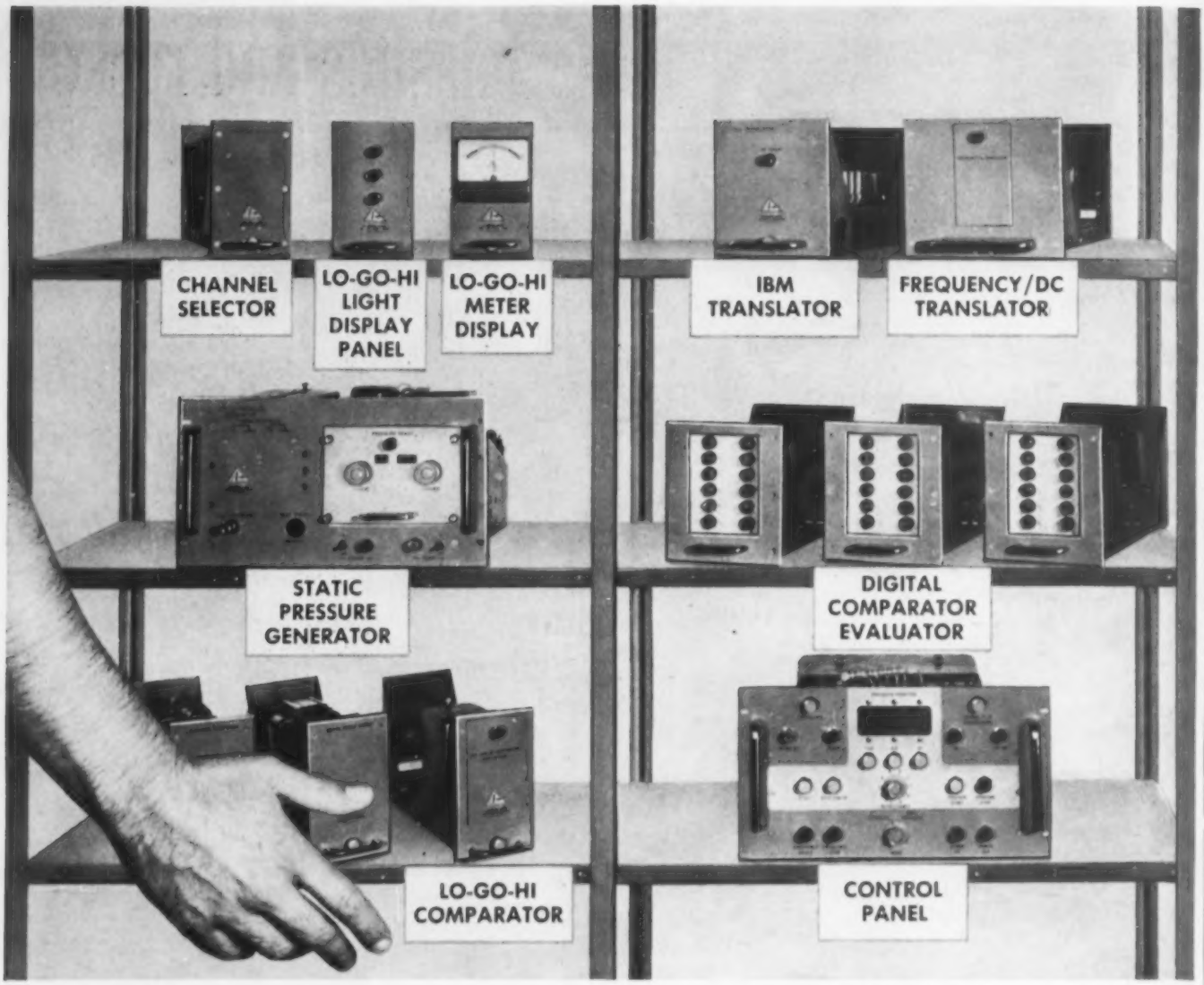
Letters 73

Contract Awards 79



cover

A scientist standing behind a glass panel and wearing protective goggles observes the test of a missile nose cone exposed to simulated aerodynamic heating conditions in a cylindrical radiator which incorporates 225 quartz-tube heat lamps. The tests are conducted at the Langley Aeronautical Laboratory of the National Advisory Committee for Aeronautics.



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We're The Best In The World!

Big deal! We have an operational ICBM! This is what the daily newspapers have been reporting in the last few days—ever since the successful firing of an *Atlas* that went some 2,300 miles (see page 17).

We read such press statements quoting unnamed "officials" as saying "now we can start turning them out like refrigerators" or "jubilant missile men were convinced today the United States has matched Russia in possessing an intercontinental ballistic missile."

In a United Press International dispatch from Cape Canaveral we caught the following: "spirits soared over the weekend in the wake of the first successful firing of a fully-powered ICBM. It assured engineers, technicians and other missile men that this country now could match Russia's asserted capability of hitting targets on another continent with hydrogen warheads."

Other sources described the successful *Atlas* firing as a "major break-through in the missile race with Russia."

Says who? Pure bunk. We object to having the American public misled into believing that the U.S. is far advanced in ICBMs when that just isn't so. A single successful firing of the *Atlas* is only an early step forward. The press agents—and USAF must be included among the guilty—have been working overtime to balloon our accomplishments above reality. The net result is to lull the public into a false sense of security. The most elementary technological advance simply doesn't comprise a "major break-through."

It appears we are getting right back to the complacent status we began to get out of on October 4, 1957. We were disappointed to read recently that even Hugh L. Dryden, who is slated to play a major role in our multi-million dollar "civilian" space agency, has publicly indicated the U.S. is not trying to catch up with the Russians because we are not in a race with them. (Hearing before the Select Committee on Astronautics, Second Session, H.R. 13619. See page 16).

Of this we are certain: if the U.S. doesn't stop being complacent, if it doesn't realize it is in a race whether it likes it or not, this nation is in dire trouble. The facts, very ably analyzed recently by columnist Joseph Alsop, are that this country is way, way behind in the ICBM race and that the Russians will be ahead of us for many, many years. Furthermore, is it just a matter of catching up with the Russians? Or should we aim at leadership and move ahead of the Russians?

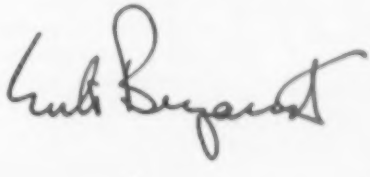
One thing is certain—deluding the public by false impressions created by the *Atlas* shoot will accomplish nothing. Our missiles are designed as offensive weapons for immediate retaliation. They must be launched—dozens at a time—instantaneously, from numerous secret bases. Countdown must be accomplished in seconds, not hours or days. We are a long way from that stage of progress.

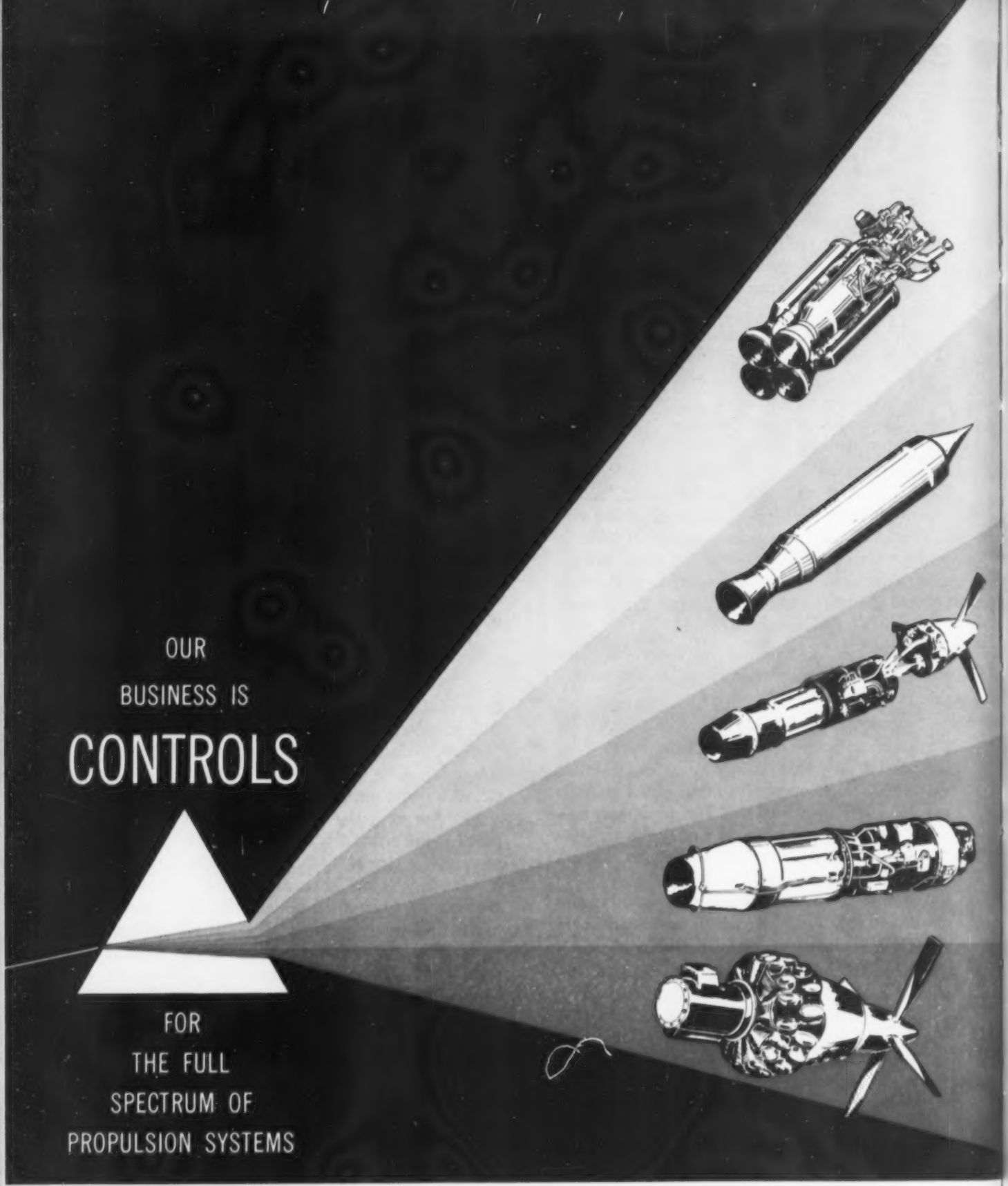
Let's face the truth and the facts. This country is far behind in the missile field. For too many years, the Pentagon ignored the missile threat. Even many in the aircraft industry were skeptical and proposed no programs. A few firms like Convair, North American, Douglas, and Boeing struggled along with meager funds. The U.S. lacked a major push. Russia's *Sputnik* produced a spark of urgency last October, but what has happened to the major drive that began getting underway at that time?

The U.S. is still in need of topside leadership. We have the brainpower to overtake the Russians, but it isn't yet being used. There is still no real spark of urgency or leadership in USAF when it comes to a forward missile program, and we are disappointed that the aircraft industry hasn't stepped to the front as many had hoped it would.

The challenge of space flight remains. The Pentagon is most unlikely to accept it. But the aircraft industry can do so. If industry can convince Washington of the real facts of life, and help plan for the future of space, we will avoid running second to the Russians in the future.

Single missile shoots are fine. But these are a long, long way from missile power in being.





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INDUSTRY COUNTDOWN

HOW'S BUSINESS?

Thiokol's net sales for the first six months of 1958 totalled $32.3 million, compared to $25.7 million for same 1957 period. But net income totalled $865,756 for '58, compared to $838,493. Figures for period compared include Reaction Motors, acquired by Thiokol as of May, '58 . . . **Consolidated Electrodynamics** reports sales of $15.4 million for first half of '58, compared to $15.2 for '57 period . . . **Temco Aircraft,** in same budget period, shows a record high sales, $61.5 million, with net earnings up 9 cents a share from '57 . . . **Clevite Corp. had sales** of $31.9 million for first half of '58, down from the '57 period, when sales were $39.7 million. Earnings dropped from $1.48 a share in '57 to $.74 a share this year . . . **Monarch Machine Tool Co.** showed net earnings after taxes of $142,717 for first half of '58, compared to $678,485 in same '57 period . . . **Ryan Aeronautical Co.** declared its regular quarterly dividend of 10 cents a share . . . **Genisco, Inc.,** declared a 7½ cent dividend . . . **Directors of Victoreen Instrument Co.** authorized redemption on Aug. 20 of $100,000 of the company's $700,000 outstanding 6% convertible subordinated debentures . . . **Shaffer Tool Works,** Brea, Calif., after 35 years of manufacturing oil field equipment, announced it was entering the field of general industrial valves—some of which might be applicable to missiles.

MERGERS AND NEW VENTURES

Airtron, Inc., completed exchanging 100% of its stock for an undisclosed amount of stock of Litton Industries, Inc. Airtron, leading producer of ferrite devices, waveguides and related components, will take over Litton's Components Division in Los Angeles, Airtron President David Ingalls becomes a Litton vice-president . . . **Sequoia Wire and Cable Co.** has acquired Hall-Scott Electronics, of Burbank, Calif., for special emphasis on work for missile and aircraft industries . . . **Pyle-National Co.,** Chicago, manufacturer of electrical connectors, fittings and lighting equipment, takes over Steber Manufacturing Co., Broadview, Ill. . . . **Cushman Precision Industries,** a new firm, has been established at Princeton Junction, N.J., to specialize in development, test and manufacture of electro-mechanical precision rotating components for electronics and missile applications . . . **Lerma Engineering Corp.** has established headquarters at Northampton, Mass., for design and manufacture of optical equipment . . . **Cosmodyne Corp.** has been formed at Los Angeles, for advanced research and development in auxiliary power and environmental control systems.

EXPANSIONS

Stauffer Chemical Co. will build a $300,000 unit at Richmond, Calif., to supply tantalum and columbium pentachlorides . . . **A new laboratory** for development of new silicone products is now being occupied by Silicone Products Department of General Electric Corp., at Waterford, N.Y. . . . **Aerojet-General Nucleonics** has completed design of a 24,000 sq.ft. engineering office and an 18,000 sq.ft. laboratory and shop at San Ramon, Calif. for nuclear reactor production . . . **Ramo-Wooldridge** announces plans for transferring its advanced electronic research operations to a 90-acre site in the Canoga-Park-Chatsworth area in Los Angeles. Plans will be final if the city Planning Department grants permission for the multi-million unit. It'll house some 2,000 scientists, engineers and administrators initially . . . **Tempo Instruments Inc.,** has moved its entire operation to a 10,000 sq.ft. plant at Hicksville, N.Y.

LATE CONTRACTS

Douglas Aircraft Inc., Santa Monica, gets a $24 million contract from Army for *Nike-Hercules* program . . . **Chrysler Corp.,** Detroit, got $16 million Army contract for work on *Jupiter* . . . **Philco Corp.** has $2.5 million Army contract for radar reconnaissance system . . . **Beckman Instruments, Inc.,** has received a $150,000 contract from Sundstrand Turbo, for an electronic system to determine efficiency of accessory power supplies for guided missiles prior to launching . . . **Packard-Bell Electronics Corp.** has a $300,000 contract from Aerojet-General to develop a missile impact prediction system for Cooke Air Force Base . . . **U.S. Borax Research Corp.**—a wholly-owned subsidiary of U.S. Borax & Chemical Corp.—got a contract from Air Force to study high-temperature inorganic polymers, and chemistry of new solid rocket propellants . . . **New contracts** totalling $1.8 million have been received by Telecomputing Corp., Los Angeles, for production of gyros used in *Nike-Hercules.*

MISCELLANY

Convair Division of General Dynamics Corp. says its nuclear laboratories at Fort Worth is working on a series of controlled fission product tests, as part of a joint Air Force-AEC nuclear propulsion safety program . . . **More than 12,000 workers** at Northrop and Nortronics Division of Northrop Aircraft got a 1-cent an hour cost-of-living pay increases August 4.

Contour machining of an aft dome for a U.S. Army missile.

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the missile week

WASHINGTON COUNTDOWN

• **AIRCRAFT-LAUNCHED SATELLITE?**—As m/r went to press—Navy was reported ready to try the first real probe of space—aircraft launch. Best information was that the probe—a 2,500 lb vehicle with a three-pound payload—will be hung on an F8U and launched at an altitude of 80,000 ft over Inyokern, Calif., possibly this week. Named *Pilot,* vehicle may include up to five stages, and seems to be far more economical than launching from a balloon, as in Project *Farside.*

• **FINANCES CUTTING SECRECY**—A sidelight on the continuing pressure on the Pentagon for economy could well be "less secrecy." Reason: paperwork on a classified project is considerable; and construction of big fences and king-sized "chemises" to cover missiles and aircraft from public view is very costly. Air Force, in particular, is pushing hard at downgrading classified information on as many projects as possible, as soon as possible.

• **WARHEADS LACKING**—There are grave implications in Atomic Energy Commission's report to Congress that, though nuclear weapons are being expanded rapidly in numbers and kind, there is still a lack of nuclear warheads for long-range missiles and anti-missile-missiles. AEC says it hopes to remedy this situation partially through current tests in the Pacific, but presumably the bulk of weapons in U.S. stockpiles are bombs of various sizes. Problem is that warheads must wait on development of missiles.

• **NUCLEAR DEVELOPMENTS**—In the same report, AEC had some interesting things to say about nuclear-powered rockets: results of research on nuclear power for long range missiles and space craft are "encouraging." First round of tests on a research rocket reactor, said the agency, will be conducted in Nevada late in 1958. Another point: There has been "significant progress" made on nuclear ramjet engines that could drive missiles of "unlimited range." And a third project, to provide nuclear auxiliary power for space vehicles (*Rover, Pluto* and *Snap*), looks "promising."

• **AUTHORITY UP—MANPOWER, MONEY DOWN**—Many Defense Department officials, who have happily looked forward to Reorganization as a source of increased authority and scope, are having some misgivings, now that the bill has been ok'd by both houses of Congress. It begins to appear that authority and workload will certainly increase—but manpower and money won't be increased so readily.

• **BATTLING RENEGOTIATION**—Major missile/aviation manufacturers continue pounding away at the renegotiation act. Latest to appear in favor of amendments was James H. (Dutch) Kindelberger of North American Aviation. Kindelberger stated that the bill introduced by Congressman C. R. King of California, providing for appeals to the courts from decisions of the tax court in renegotiation matters, should be supported. "Otherwise," he commented, "the tax court becomes a trial court and appellate court as well." And, he added, the tax court is so swamped that it has petitions from major aircraft companies that it hasn't been able to act on in two years.

• **MORE ON SECRECY**—There's a great deal of importance to missile-men in that bill the Senate passed last week (and sent to the House) aimed at preventing federal officials from "arbitrarily withholding" information under a 1789 statute. That old statute authorized department heads to make regulations for the "custody and use" and preservation of records. The new bill adds this significant sentence: "This section does not authorize withholding of information from the public, or limiting the availability of records to the public."

$6.596 Billion For Missiles This Year

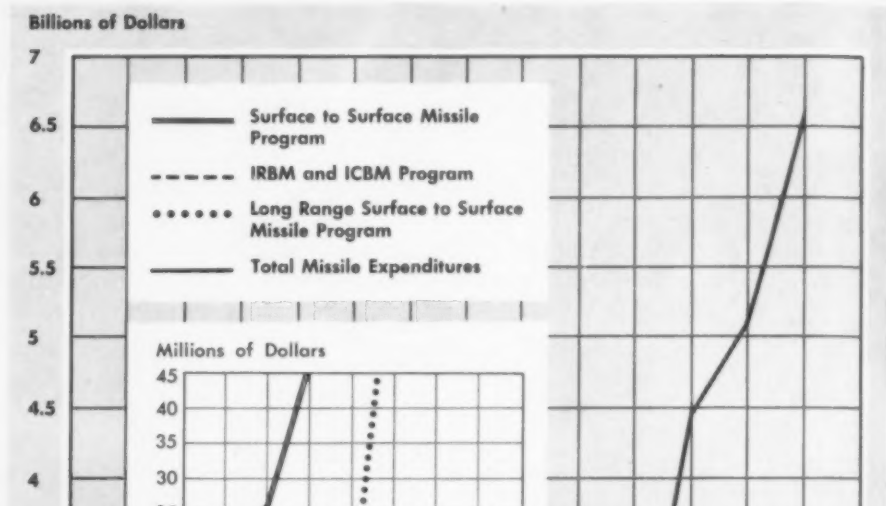
by Seabrook Hull

Missiles and space flight become a $6.596 billion business in fiscal year 1959—the 12-month period starting July 1, 1958 and ending June 30, 1959.

Recently compiled figures of the Department of Defense show that programmed obligations (roughly speaking, what's available to Army, Navy, Air Force and the Defense Department to be placed in the form of contracts) for 1959 for all missile procurement, construction and research and development, comes to $6.596 billion, compared to $5.107 billion in Fiscal Year 1958.

This is the first time that the Department of Defense has really had any concrete idea of the impact of the missiles and astronautics business on the national economy. Graphs and charts accompanying this article demonstrate the growth. There is no indication that this growth will level off anytime soon. In fact, the prospect of upcoming space flight spending requirements staggers Washington's budget-minded planners.

No firm figures have been developed to show the actual comparable level of expenditures—cash and checks paid out for work performed—for the missile business as a whole. However, experience shows that expenditures normally follow obligations by between 10 and 18 months. If this holds true—and it probably will—it means that Uncle Sam will actually pay out a little over $5 billion in Fiscal '59 for missile-based weapons systems and space flight projects. In fiscal 1960, expenditures will top $6 billion.



GRAPH SHOWS THE SHARP RISE in programmed obligations for missile systems. The box is merely an enlargement of the earlier years.

• **How much for R&D?**—Other figures developed by the Defense Department emphasize the state of the art. Contracts to be placed by Army, Navy and Air Force for missile research and development activities alone this year come to $610.7 million, not including Advanced Research Project Agency's $520 million, which would bring the total to $1,130 billion.

However, add in test and evaluation programs like the firings at Cape Canaveral, cold-weather tests at Fort Churchill in Northern Canada, and the total being spent to develop and then to prove weapons systems based on missiles comes to $1.923 billion—not including ARPA.

• **Figures add up**—The difference between this research, development, test and evaluation total and the full $6.596 billion in programmed obligations for all missile-related work lies in orders for production missiles, construction of missile bases, and orders for directly concerned support equipment.

For example, this takes into account costs of converting Navy ships to missile-launchers but not the basic cost of the ships themselves.

Exceptions are the submarines required for launching *Polaris* missiles. Since these submarines will have only one basic use, and since they are essential to the success of the *Polaris* concept, the full charge of the *Polaris*-launching submarines is included.

This program, incidentally, is a good example of how expensive missilery is getting. The total worth of the *Polaris* program so far is $1.25 billion, including research and development contracts on the bird itself and funds for the first five submarines. This figure does not include funds for the extra four subs that Defense didn't ask for, but Congress authorized.

On the extra money being voted by Congress, Defense Secretary McElroy had this to say: It will give the Defense Department greater flexibility in its operations. McElroy didn't say he wasn't going to spend it, but he won't spend it unless he thinks it's worthwhile.

For example, the Secretary sees no point in laying the keels for the four extra *Polaris* submarines until there is greater assurance that the *Polaris* concept isn't going to encounter any unanticipated snags. The Navy will be allowed to order some $15 million worth of long lead-time components per submarine right away. But if *Polaris* runs into long delays, these components can be used on any nuclear-powered submarine.

The same philosophy is being ap-

plied to *Minuteman*, over which McElroy thinks Air Force publicity is "prematurely enthusiastic." For *Minuteman* to be a practical weapon, either guidance or propulsion, or both, need material improvement before the full bird can be ordered into final R&D as weapons system.

• **Includes all procurement**—The $6.596 billion of programmed obligations for missile systems in the current fiscal year includes all procurement, construction and research and development funds directly associated with missile programs.

Military Research & Development Appropriations
($ in Million)

FY	missiles	total
1955	214.0	1,349.6
1956	280.4	1,539.0
1957	355.8	1,651.4
1958	424.0	1,720.1
1959	1,130.7	2,493.1

These figures do not include military pay, operation and maintenance costs for operational missile units and sites, and include only those shipbuilding and aircraft costs directly associated with providing missile capability.

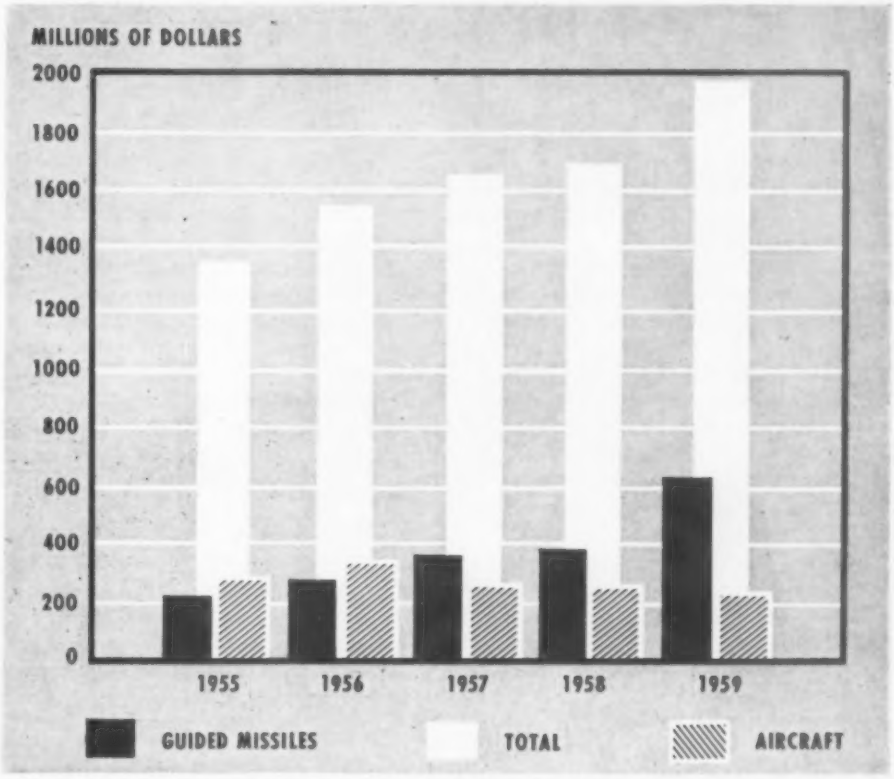
Of this total, $2.430 billion are earmarked for IRBM and ICBM systems; $95 million for other long-range surface to surface missiles (*Regulus, Matador*); $593 million for the shorter range surface-to-surface missiles like *Little John, Honest John, Redstone, Lacrosse*; $3.478 billion for all other missiles such as surface-to-air (*Bomarc, Nike* series, *Talos*), air-to-surface (*Bullpup, Rascal*), underwater-to-surface (*Subroc* but not *Polaris*).

These figures also show that by the end of fiscal '59, contracts total $6.568 billion that have been placed for big ballistic missiles since 1946, including the Air Force MX-774 (pre-*Atlas* study), *Atlas, Titan, Thor, Jupiter* and *Polaris*.

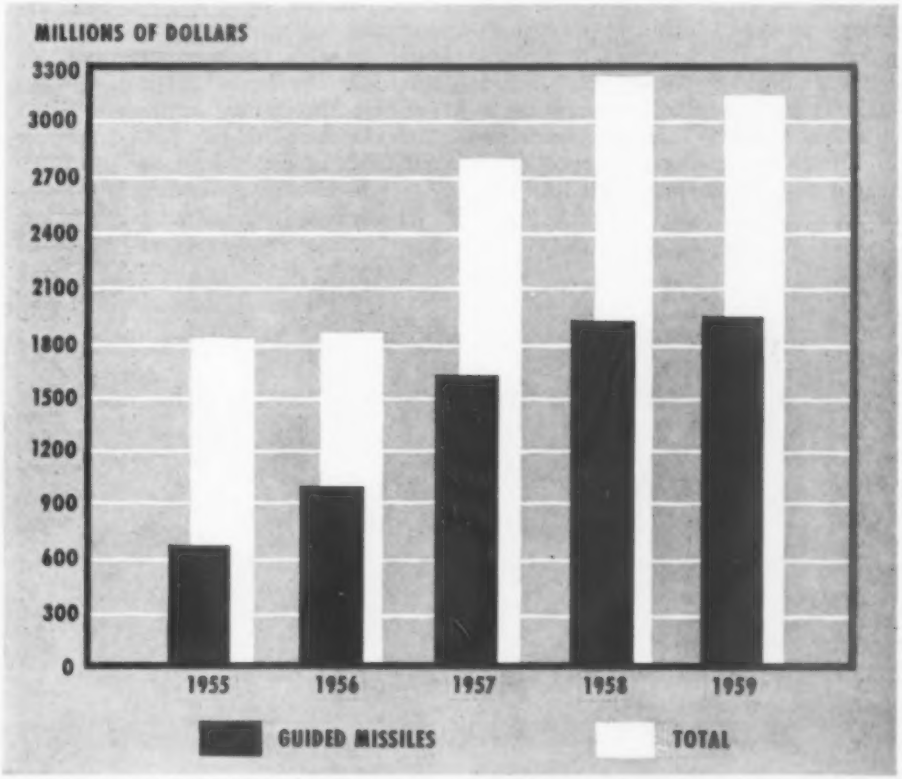
The grand total of U.S. contracts placed for missile systems research, development, construction and production for the 14 years from 1946 through 1959 comes to an impressive $24.429 billion. Prospects are that this much will be spent again in the coming years of 1960 through 1962, including, of course, expenditures for space flight projects.

The Pentagon's next big statistical job in relation to missiles will be to attempt to find out, industry-by-industry and commodity-by-commodity where this money goes. This task will be made immensely easier once the Missile Manufacturers Planning Reports (m/r, July 25, p. 12) have been sent out and returns begin coming back from the companies that make missiles. At the moment, the Pentagon has no idea of the detailed impact this massive spending is having on the national economy. Similarly, there is no way of knowing right now, just how far or how fast missile system production could be expanded in an emergency.

The odds are, however, that both this information and a breakdown of where the money is going will be available within 12 months.



BAR CHART COMPARES the programmed obligations for research and development, comparing aircraft (dropping), missiles (rising), to the total.



HERE IS A COMPARISON of programmed obligations for research, development, test and evaluation between missiles and the total for all weapons systems.

AF Re-establishes Space Office

With the full cooperation and approval of the Advanced Research Projects Agency and the Department of Defense, the Air Force this week reestablished, in name, a space technology office under Brig. Gen. Homer A. Boushey.

Formerly known as the "Director of Astronautics," Gen. Boushey now—as "Director of Advanced Technology" in the office of the Deputy Chief of Staff/Development—will head the key air staff activity concerned with advanced technology and all AF matters pertaining to space. The office will work closely with ARPA, the Departments of the Army and the Navy, and the newly designated NASA.

Shortly after setting up Gen. Boushey's office last December, as the office of the "Director of Astronautics," DOD ordered suspension of the title because it was considered "contrary to assurances given the Secretary of Defense that no such action would be taken until it could be coordinated with the specific plans for the new agency in the Department of Defense."

"This office," Gen. Boushey said, "will supervise at Air Staff level the formulation of an AF advanced technology program, including space technology."

Additional responsibilities include maintaining liaison with educational institutions, industry and representatives of foreign governments engaged in research and development activities.

The office will have cognizance of all Air Force study projects, such as earth orbiting, orbiting the moon, development of space navigation systems, methods of transfering material and personnel from one vehicle to another while in orbit, and related matters.

It is understood that the Air Force, in cooperation with other agencies, is planning other projects, including possible space probes to Mars and planets, which might follow successful moon probes. However, indications are that such projects are still in the pencil-and-paper-stage, and cannot be anticipated in the immediate future.

• **Dyna-Soar too**—Among the projects which will come directly under the Air Force and Gen. Boushey is the Dyna-Soar system. The General pointed out that this, in actuality, is not a space program but a boost-glide system. He admitted that it was possible that Dyna-Soar could later be adapted to space flight.

Contracts were recently awarded to Martin-Bell and to Boeing Airplane Company, and may continue for as long as 12 to 18 months. However, Gen. Boushey said that as soon as one company or the other proves to be more capable, a contract would be awarded. The study competitions costs are being taken over by the Air Force, but both companies are putting substantial funds of their own into the studies.

Gen. Boushey, who made the first U.S. flight powered by rocket propulsion, told Congress last spring that the moon could be used as a base to fire rockets accurately at the earth.

PHOTOGRAPHS AND DATA on the latest Japanese sounding rockets indicate a remarkable advancement in the state of the art. Both of the rockets shown were developed by Professor Hideo Itokawa, Institute of Industrial Science, University of Tokyo. Itokawa is head of Japanese IGY sounding rocket program. K-150 rocket (left). Single-stage, solid propellant sounding vehicle fired April 8, 1958. Diameter—150mm. (5⅞ in.); length—3.3m (10¾ ft); weight—70kg (154 lbs). *Kappa* Type V two-stage rocket (right) fired April 29, 1958. First stage diameter—220mm (8⅝ in.). Second stage—K-150 rocket. Maximum velocity—about 1,000 m/sec (3300 ft/sec).

SRI Obtains New Data On Liquid Fuels

New data on the specific conditions needed to ignite liquid monopropellant missile and rocket fuels has been obtained by propellant research specialists at Stanford Research Institute.

An electrolytic liquid monopropellant, hydrazine-mixed with hydrazine nitrate and water, was subjected to electrical discharge from an electrode protruding into the liquid. Various voltages were applied to electrodes of different shapes.

When voltages above a critical value were applied to the electrode, an electrical discharge, apparently similar to gas coronas, was formed at the electrode tip. Lasting about 30 millionths of a second, the corona is believed to consist of streamer-like filaments of plasma.

Study of the corona revealed that when ignition takes place, a self-sustaining reaction zone is formed. Expansion of this zone progressively converts the surrounding liquid propellant into high-pressure, high-temperature explosion products.

By varying the electrode voltage, it was found that the amount of energy delivered per unit volume of the corona is a factor in assuring ignition. Results indicate that at least 15 calories of energy per cubic centimeter of corona are needed. On this basis, it may be possible to obtain ignition with very small coronas and energies as low as one calorie.

SRI's program was sponsored by Army Ordnance and supervised by Dr. Marjorie W. Evans, senior physical chemist at SRI.

X-15 Control Jets To Be Manufactured By Bell

Tiny control jets which will be placed in the nose and wing tips of the X-15 are being manufactured by Bell Aircraft Corp., Buffalo. Purpose of the jets is to help the pilot steer the research aircraft once it leaves the earth's atmosphere.

The tiny jets, which are operated by a four-way thumb operated switch, shoot out a vapor created by hydrogen peroxide passing over liquid oxygen. By pressing the switch forward, the jet vapors cause the nose of the plane to drop. Pushed back, the switch allows the left wing to drop.

In the earth's atmosphere, the plane would be steered by conventional methods.

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Dryden Denies "Race" With Reds

by Frank G. McGuire

The probable head of the nation's new civil space administration, Dr. Hugh L. Dryden, now director of the National Advisory Committee for Aeronautics, told a congressional committee that NASA's space program is not aimed at keeping up with or being competitive with the Soviet Union—and that he is opposed to anything like a "crash money program to leapfrog Russia."

Dryden made his comment to the House Select Committee on Astronautics and Space Exploration.

An ARPA spokesman told m/r that NASA's space program before Congress "is practically word for word the program which we spent several months preparing." However, he added, although ARPA had assigned "conservative" costs to its purely scientific space program, NACA, in most cases, cut the figures "in half."

Dr. Dryden declined to encourage the House committee to approve double the amount that was proposed as the NASA budget, even though he said he thought this is what would be needed to overtake Russia in the future. He said the present budget was enough, and there would be ample time to ask for more money when present plans are evaluated.

The President has sent to Congress a request for $125 million in new money, and has ordered the transfer of $117 million from the Defense Department, principally from ARPA (see also p. 74). There is also available the $101.1 million appropriated to NACA. The House and Senate have already approved a $47.8 million authorization bill for NASA equipment and facilities.

The ballistic missile program, Dryden said, has the highest priority, "and I, as well as other people, am more concerned about whether we have a stock of missiles ready to operate intercontinentally, than I am about doubling or tripling the amount of money in the (civil) space program at this time." He said he felt there would be an adverse effect on the military program if too much were diverted into the NASA programs.

Lee Metcalf (D-Mont.) commented after Dryden had testified, that "it would be a tragic thing for the nation if the President appointed Dryden head of NASA."

The committee hearing brought out these points:

Within the next twelve to eighteen months, *Atlas* boosters will be available to orbit satellites of 100 to 700 pounds at altitudes of 300 miles. Dryden said that if an *Atlas* were needed, it would have to be ordered now for delivery in nine months, or else be diverted from the ICBM program.

The 1 to 1½ million-lb.-thrust rocket engine is being transferred to NASA from ARPA as part of the new agency's responsibility. This powerplant is expected to orbit a 40,000 pound payload in a 300-mile orbit.

NASA hopes to have a 100-foot spherical reflector in orbit by late FY 1959 or early FY 1960 for communications purposes.

Specific impulses of 360 seconds have been attained at the NACA Lewis Laboratory using hydrogen and fluorine, and nuclear engines are expected to develop 1,200 seconds specific impulse.

Preliminary tests of a 2,200-pound manned satellite vehicle will get underway soon, with first manned flight possible within a year (though not actually placed in orbit). *Atlas* is planned as launching vehicle, with overall costs being broken down as follows:

Development and construction of models and full-scale (about 7-foot diameter) capsules—$6.5 million.

Instrumentation for model and full-scale flight capsules—$4 million.

Booster systems for five models and two full-scale flight capsules (These include instrumented and small-animal flights)—$19.5 million.

NASA's proposed budget for research and development on advanced components and techniques includes propulsion systems, $30 million; vehicular subsystems, $28.5 million; instrumentation, $7 million; special vehicles, $16.5 million; communications and meteorological satellites, $10.5 million.

Development of midcourse guidance for flights to planets will soon get underway.

NASA wants a stabilized platform in satellites to hold at least 2,000 pounds for mounting of astronomical telescopes. A similar experiment would involve an atomic clock to test the theory of relativity.

The total personnel assigned to NASA will be close to 10,000 persons by 1959. This includes the present 8,200 of NACA personnel and an additional 1,800.

NASA to be Included In Renegotiation Act

In a move virtually assuring Congressional approval, the House Ways and Means Committee has reported out a bill to expand the Renegotiation act to include the National Aeronautical and Space Administration and to extend the present act, with only one other change, for another six months. The present Renegotiation Act is due to expire December 31, 1958. The extension would keep present provisions in force through June 30, 1959.

The one change the committee approved would allow private firms to appeal decisions on excess profits to the U.S. Court of Appeals, whereas under present provisions, the U.S. Tax Court is their last resort.

Congressional passage of the bill and a Presidential signature are virtually assured. This does not mean that industry efforts to get present provisions modified have failed. To the contrary, it means that Congress is not satisfied with the bill as it stands and wants more time in which to consider proposed alterations.

NASA Facilities Budget Breakdown

Congress has approved $47,800,000 in new capital facilities for the National Aeronautics and Space Administration. This is in addition to $26,220,000 already approved for NACA, of which the majority is applicable for space research. Here is the capital facilities breakdown:

Wallops Island: Two intermediate range-type rocket launching facilities, $4,680,000 (for testing of hydrogen-fluorine combinations), land acquisition, $600,000; design and engineering services, $537,500; instrumentation of range, $12,500,000; erosion control, $137,000.

Space Projects Center, Beltsville, Md., $3,750,000 including erection of two buildings, equipment and instrumentation.

General equipment and instrumentation for tracking of satellites, $19,500,000. (NASA will take over present IGY network, the Vanguard computing center in Washington, and will make use of optical stations operated by Smithsonian Institution).

Langley Aeronautical Laboratory: High-temperature structural dynamics facility, $12,120,000.

Ames Aeronautical Laboratory: Hypersonic helium tunnel, $1,685,000; hypervelocity research laboratory, $1,450,000; modifications to flight research laboratory, $1,186,000.

Lewis Flight Propulsion Laboratory: Modifications to rocket altitude research tunnel, $512,000; hypersonic missile propulsion facility, $2,690,000; modification of materials research laboratory, $2,080,000; high-energy rocket engine research facility, $1,800,000.

Atlas Reaches Full-Power Tests

by Norman L. Baker

The first successful flight last week of the full powered (three-engined) *Atlas* B is convincing evidence that, although, the missile is far from operational status, it has entered the final phases of the engine flight test program.

Last week's test was only the first in a series of engine compatability tests. Launched with a reduced propellant load, the *Atlas* went through full duration booster engine burning and separation and a limited sustainer engine operation. Sufficient impetus was generated to thrust the missile to an impact 2,500 miles downrange, one-half of its design operational range.

This was the second flight of the *Atlas* B model—the first marriage of the three-engine cluster ended in failure after 45 seconds of flight. The August 2nd flight was the first with an operational nose cone configuration.

• **Testing program**—Many test flights remain before the *Atlas* becomes a working weapon of the Air Force First Missile Division.

For example, an operational *Atlas* flight sequence program will perform the following functions: The vernier engines, located on each side of the missile and approximately one-fourth of length of body from the base, will be ignited five seconds before main engines are ignited.

Main engines (twin boosters and sustainer) will be ignited simultaneously, and quickly develop maximum sea-level thrust. At lift-off from the pad, boosters are producing 150 K each (K equals 1,000 lb.) and sustainer 54 K (total thrust of 354,000 lb.). The vernier engines provide additional attitude control during this phase.

After 140 seconds of burning, the two booster engines, plus the base frame, drop away. By the time of booster burnout, the engines are developing about 165 K due to increased efficiency at high altitude. The sustainer, now with a high altitude thrust of 60 K, continues to burn for approximately another three minutes for a total burning time of five minutes.

During sustainer flight, the verniers supply thrust control adjustment, in addition to roll and attitude adjustment. Thrust of the verniers range from 800-lb. at sea level to about 1 K at upper altitudes.

Vernier engines continue to burn for 15 seconds after sustainer cutoff, to obtain terminal velocity adjustment. At the instant of final velocity attainment, the nose is separated from the missile proper.

Small retro rockets provide clean separation of the nose cone. The retro rockets are solid propellant units supplied by Atlantic Research Corp. The nose cone is then oriented for correct re-entry attitude, probably by small steam jets located on the periphery of the underside of the package.

• **Much depends**—Therefore, the "1½-stage" *Atlas*, actually a two-stage missile, requires the reliable, full duration operation of at least eight separate rocket propulsion units before its payload can be placed within a reasonable target radius 5,500 miles distant. Only four of these engines have been tested for full duration operation. The three main propulsion units must undergo at least two or three more test flights before a full range flight is conducted. The Air Force reports that this is three or four months away.

Finally, the missile will enter the operational nose cone re-entry test phase of the program. The nose cone on the latest flight, although an operational cone in configuration, is not believed to have been fabricated for re-entry endurance. Currently, the operational target date is late 1959.

Convair Astronautics prepared the first preliminary designs for the *Atlas* during 1946-47. Defense Department economy cutbacks in 1947 led to shelving of ICBM development, although Convair continued its studies until 1951 with its own funds. Full recognition and a top priority was assigned in 1954.

First launching of an *Atlas* was on June 11, 1957; and the first fully successful flight came on Dec. 17, 1957.

The Air Force back-up ICBM, the Martin *Titan*, is expected to start static tests at Cape Canaveral within the next few weeks. The 40-foot second stage of the missile was airlifted last week to the test range aboard a C-124 Globemaster. Static tests will await the arrival of the first stage which is still at Denver undergoing vibration tests.

The *Titan*, at the end of the third year of development, is expected to start first flight tests by the end of this year. Reliable sources have stated that the *Titan* development program could have been shortened by as much as 6 months, but was bogged down by indecision of the missile's future. The two-stage 92-foot missile will be a more efficient carrier system than the *Atlas*, a straightforward function of its staging arrangement.

Date Dubious for Lunar Probe

by Donald E. Perry

Advanced Research Projects Agency has serious doubts that it can meet a firing date within the next few days for its first lunar probe.

Late last week, ARPA had made no firm decision on a firing during August of the *Thor-Able* launch rocket, because of incomplete recommendations from other key agencies. However, ARPA Director Roy W. Johnson said at a press conference that an Allegany Ballistic Laboratory rocket had been selected as the third stage, and that a command guidance system would be used in order to achieve higher reliability.

Best time to fire the probe is when the planes of the earth and moon orbits around the Sun are in line. First of these periods is August 17-20, next is Sept. 14-16. With the use of command guidance to put the terminal stage into orbit around the Moon, the chances are probably 30-70 for success.

ARPA emphasized that the first attempt is merely a test of components at altitude, and it is not anticipated that a Lunar orbit will be achieved. However, with a terminal stage triggered at about 50,000 miles from the moon, possibly would orbit—but would make no more than six turns before vectoring into space.

The decision to use the Allegany rocket was made only two hours before Johnson's press conference. The third stage will contain clusters of vernier engines for additional thrust above the needed 25,000-mile per hour escape velocity.

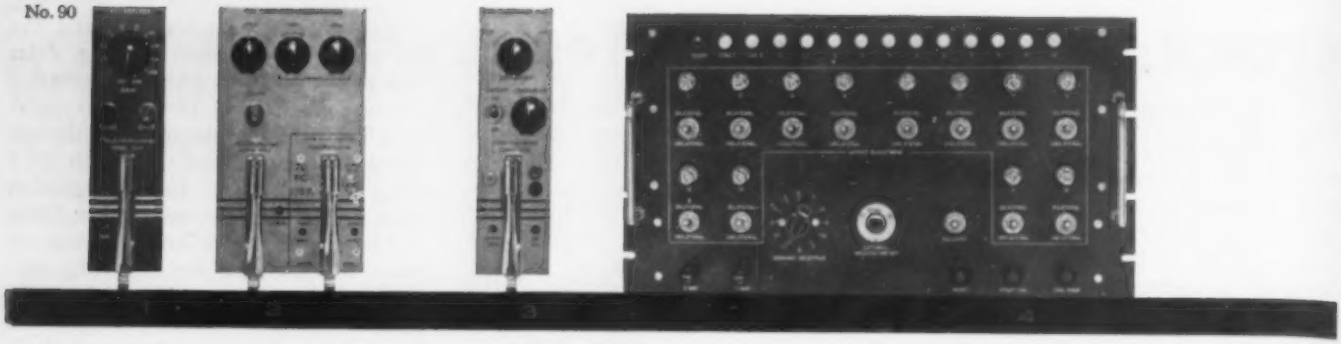
Johnson said the probe vehicle would achieve a speed of about 35,000 feet per second.

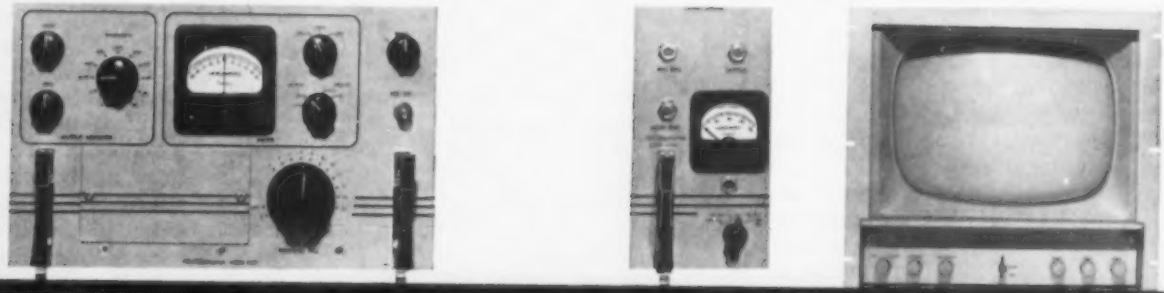
The terminal stage, shaped like a doughnut with the rocket in the center, will be gyro stabilized to allow a photo-electric cell-principle mechanical scanner to take crude photos of the Moon's surface, for transmission to earth electronically.

Payload will be 30 lb. of instrumentation. Although total weight of the terminal stage—to be triggered from the Hawaiian Islands—will be 60 to 65 pounds. More than 50 percent of payload weight will be batteries, broadcast will be on 108 megacycles.

Johnson said that of the five moon shots programmed, the first three will use the *Thor*, but, if one of the two Army probes are ready, in the interim, the Army vehicle will be "put on the pad."

No. 90





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Manufacturer Gives Funds to Aid Engineer Students

The Aerojet-General Corp. has made a $13,500 grant to the Sacramento State College Foundation, with a view toward helping the college expand its output of engineering students and graduates.

Elmer E. Nelson, Aerojet's resident manager for Administration, said in a letter accompanying the grant.

"These funds are for the purpose of assisting in developing and improving the engineering curriculum of Sacramento State College. The main purpose that our organization has in mind is the acceleration of courses leading to a degree in engineering, so that it will be possible for the college to graduate engineers at the earliest possible date.

"The funds being granted are in no way to be used to supplant or reduce the amount of appropriations being made to the college for its regular operations. These funds are, rather, to supplement and augment such budgetary appropriations in order to achieve the desired ends."

Aerojet is a subsidiary of the General Tire and Rubber Company.

Lockheed Credits Missiles in Biggest Earning Gain

Missile work got a large share of the credit last week for Lockheed Aircraft Corp.'s highest first-half earnings volume.

The corporation's midyear earnings report showed earnings of $9.7 million, a jump of 29% over the $7.6 million in the same period last year. Sales for the first half of 1958 were listed at $465.7 million, up nearly 10% over the $425 million registered in the first half of 1957.

A sales breakdown showed the heavy increase in missile work, amounting to more than a quarter of the total business of the company. Missile and satellite development work stood at 27% of sales, at $123.8 million. Work on five models of Air Force craft accounted for 31%, at $146.9 million.

According to Robert E. Gross, chairman of the board, Lockheed's June backlog of orders stood at $1.215 billion at the end of June this year, compared with $1.280 billion at the end of 1957.

The backlog figure, however, does not include large missile contracts now under negotiation. Lockheed's space vehicle program involves principally the *Polaris* ballistic missile for the Navy and an Air Force Earth satellite; and high-speed target systems for both the Air Force and the Army.

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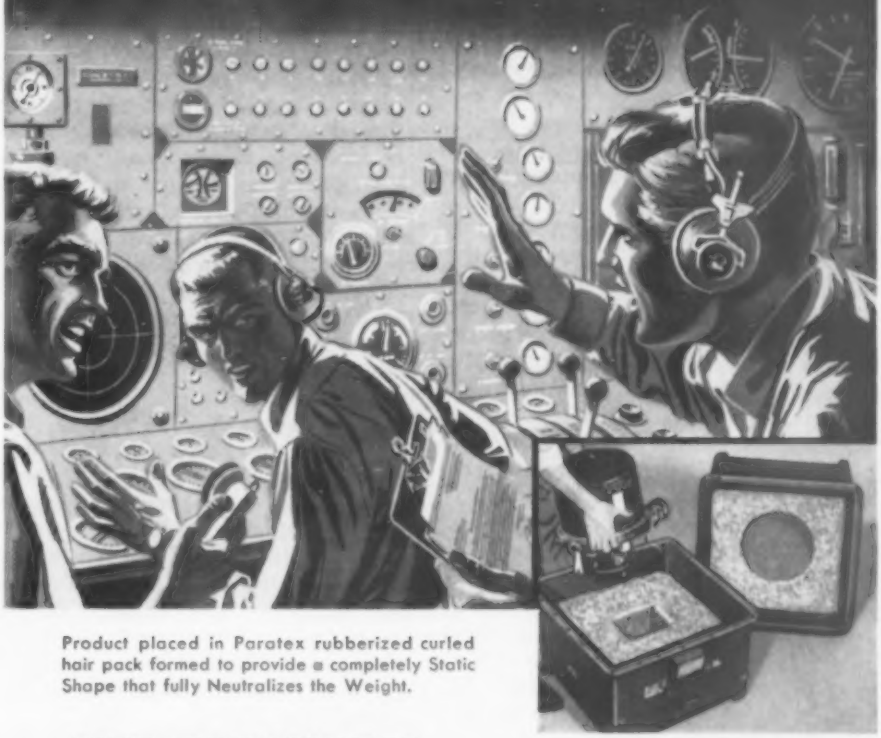

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Explorer IV Most Far-reaching IGY Probe

Instrument-packed Satellite To Find Boundaries, Effect Of Radiation Barrier; May Explain Aurora

by Dr. Ernest Stuhlinger*

Explorer IV was built in a hurry. It has but one mission: to ferret out the mysterious and very intense radiation discovered by *Explorers* I and III near the equator, at altitudes above 600 miles.

Even though indications of this strange radiation was present in the records of *Explorer* I, the high intensity was so unexpected that recordings were at first interpreted as temporary failures of the measuring instruments. The number of rays impacting during every second on the Geiger-Muller counter was so great, that Dr. James Van Allen of Iowa State University, who designed and built the cosmic ray measuring instruments for *Explorers* I and III, thought that the counting circuit did not work properly at times.

The periods of failure happened to coincide with the times at which *Explorer* I was going through the distant portions of its orbit. So *Explorer* III was equipped with a magnetic storage tape which recorded the cosmic ray counts continuously during each full revolution and then played them back quickly while passing over one of the receiving stations.

The cosmic ray counter and the recording and playback devices in *Explorer* III worked for about 40 days. More than 500 playbacks revealed a picture of the cosmic ray intensity which was most alarming.

While the number of cosmic rays measured by the Geiger counter followed the anticipated curve rather closely from the surface of the Earth up to about 600 miles, the intensity took a very steep upswing at higher altitudes. This upswing was steepest in a belt close to the equator. In more northerly and southerly latitudes, it was still far above the expected rate.

• **Higher than expected**—With the counter size used in *Explorer* III, about 70 counts per second could be expected. Instead, the counter reached its maximum counting capability of about 35,000 counts per second at an altitude of 650 miles. *Explorer* III went through a peak altitude of 1,600 miles at its apogee. It is not yet known how many counts an ideal counter would register there but a tentative estimate by Dr. Van Allen indicates that this number may be a thousand times higher than previously assumed.

From all that can be concluded from the measurements of *Explorers* I and III, it appears likely that this newly discovered radiation consists of electrons of relatively low energy. They are emitted by the sun, and they travel in all directions out into space. Those electrons which come close to the Earth fall under the influence of the Earth's magnetic field. Their paths are bent by the magnetic force in such a way that the electrons travel on spirals which follow in general the magnetic field lines. However, the electrons do not continue all the way to the magnetic North or South Pole.

Since the magnetic field strength increases towards the poles, the spirals condense like a compressed spring and before reaching the denser layers of the atmosphere, the electrons bounce back in spirals which again follow the field lines, but now towards the opposite pole. Upon approaching the other pole, the spirals compress again, and finally the electrons reverse their general direction.

In this fashion, they oscillate back and forth on spirals between the magnetic poles. The Earth's magnetic field acts like a trap which catches the electrons and keeps them until they collide with one of the residual air molecules at lower altitudes near the poles.

• **Reason for Aurora**—Such a collision normally causes the molecules to emit visible light and this effect is what is observed as "northern lights" or the Aurora Borealis.

Although the Aurora and its causes have been studied for ages, it was not previously known that electrons are trapped in the Earth's magnetic field in such great numbers.

The Earth's field acts not only as an electron trap, but also as a huge reservoir for electrons. Many of them leak out of this reservoir by collisions with air molecules, but their number is continually replenished from the sun. The average lifetime of an electron in this reservoir is of the order of a few hours.

It is estimated that an area of one square inch, at an altitude of 650 miles above the equator, is hit by about 50 million electrons per second. The energy of these electrons seems to be relatively low, mostly of the order of 0.1 million electron-volts. They can be absorbed by even a thin layer of metal or plastic, but many of them produce X-rays in such an absorbing layer. The radiation measured in the *Explorers* I and III experiments consists actually of these X-rays.

• **Far reaching effects**—The implications and consequences of this high altitude radiation are far-reaching. Geophysicists will be able to understand the heat balance of the atmosphere much better than they do now. Problems like long-range weather forecasting or climatological predictions would be much easier to solve if we knew more about the total energy influx into the atmosphere.

The significance of this new radiation for the development of space travel is very obvious. Depending upon its intensity, energy and distribution, our future space vehicles may have to be surrounded by radiation shields, not only to protect the human space travelers but also to keep photographic films, transistors and insulators from being over-exposed to radiation. Even radio communication between space vehicles and Earth may be influenced by this abundance of cosmic electrons.

The satellite carries two Geiger counters, one with a thin lead shield around it, the other one unshielded. Their counting rates are reduced by electronic scalers in order to alleviate the problem of signal transmission by radio.

In addition to the Geiger counters, the satellite is equipped with two scintillation counters. These instruments contain a translucent crystal of cesium iodide or sodium iodide, or just a piece of clear plastic. This so-called scintillator is mounted in front of a photo-multiplier tube. When an electron, or another particle, or even a photon strikes the scintillator with sufficient energy, a minute light flash of extremely short duration is excited.

There is no tape recorder on *Explorer* IV. The data is transmitted continuously by two transmitters, one phase-modulated, the other amplitude-modulated. Each transmits the signals of all four counters. A considerable number of ground stations are ready to pick up and record the signals.

They are spread out over the whole globe. From Chile to Alaska, and in each of the four other continents, there are receivers operated by International Geophysical Year crews, by military stations, and by universities. They will record the satellite signals on tape and ship the tapes to Iowa State University.

**Director, Research Projects Laboratory, Army Ballistic Missile Agency.*

Editorial Promotions Announced for m/r

Promotion of Erik Bergaust to the position of editor of MISSILES AND ROCKETS magazine and appointment of Col. F. Clarke Newlon, who retired from the USAF July 31, as executive editor, has been announced by Wayne W. Parrish, president and publisher of AMERICAN AVIATION PUBLICATIONS.

Col. Newlon, who succeeds Mr. Bergaust as executive editor, effective September 1, was the assistant to the Director of Office of Information Services, Headquarters, USAF. On continuous active duty from July 1942, he had a series of important assignments in the AF Office of Public Information covering the entire range of Air Force operations, including guided missiles and rocketry.

Prior to entering the armed services, Col. Newlon worked on the Omaha WORLD-HERALD, Kansas City JOURNAL-POST, Chicago TIMES, and the Dallas DISPATCH in various positions, including reporter, city editor and managing editor.

Mr. Bergaust, now editor, was managing editor of MISSILES AND ROCKETS from its first issue in 1956 and was promoted to executive editor in 1957. He is the author of several books on astronautical subjects, a member of the Information Advisory Group to the President's Committee on Scientists and Engineers, and president of the National Rocket Club.

ARPA Future Role Not Clearly Defined

The role of the Advanced Research Projects Agency under the new military Reorganization Act isn't yet defined, it became clear last week from defense sources.

A high defense official pointed out that it has not been resolved whether the new Director of Research, Engineering, will be boss of all research programs; or whether both ARPA and the Director of Guided Missiles will continue to go their own ways, with the Director of Research, Engineering, continuing in an undefined role, working on items not otherwise assigned.

In his original messages, President Eisenhower made it clear that the Director of Research, Engineering, would head all research and engineering within the Department of Defense, working directly under the Defense Secretary. However, at later news conferences, Defense Secretary McElroy said that both ARPA boss Roy Johnson and Guided Missiles Chief William M. Holaday would continue to report directly to him.

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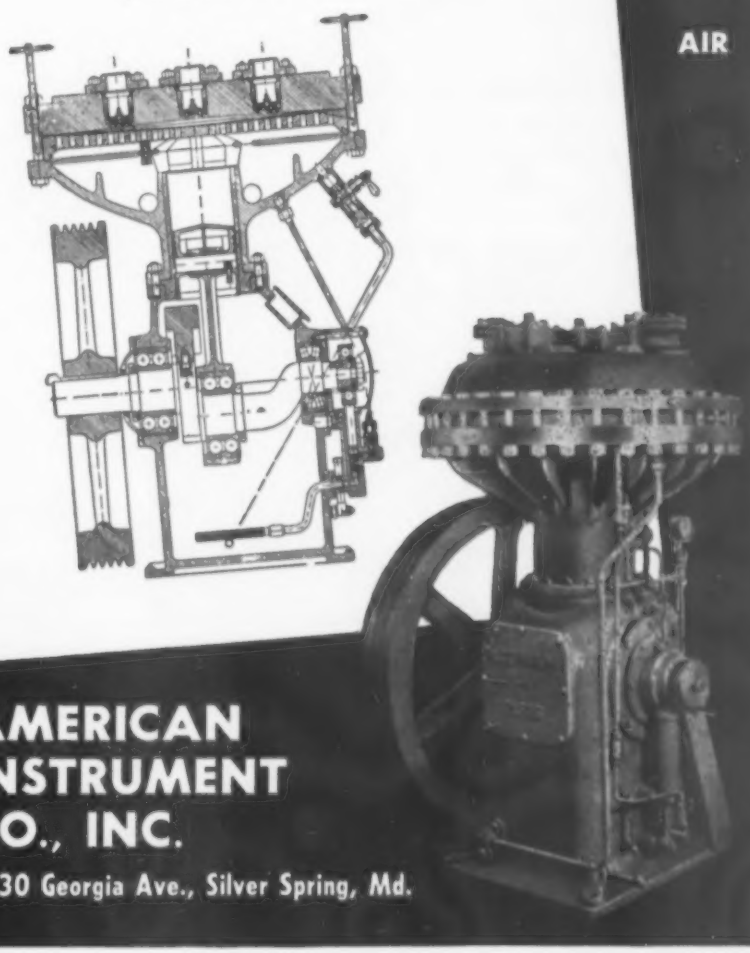

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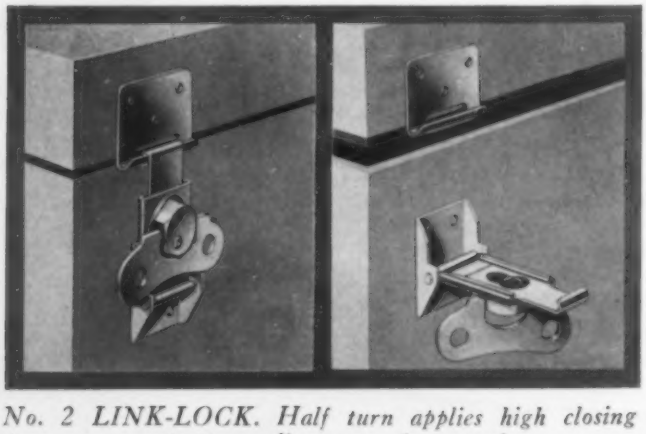

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Major Ultrasonics Firms Merge into New Company

Two leading manufacturers of ultrasonic equipment used in missiles and industrial applications have joined forces through a merger, it was announced last week.

Accoustica Associates, Inc., acquired The General Ultrasonics Company, by issuing 25,872 shares of its common stock to General's stockholders. General will now be operated as a wholly-owned subsidiary of Accoustica, with Stanley R. Rich continuing as president.

The total staff of the two organizations is nearly 300, in seven plants located at Mineola, N.Y.; Hartford, Conn., and Culver City, Calif.

AEC Awards Contracts To Study Space Effects

Forty-five "unclassified life-science" research contracts in the fields of medicine, biology, environmental sciences and radiation instrumentation were awarded last week by the Atomic Energy Commission.

Among them were: A $15,120 grant to Meharry Medical College for a study of the effect of X and Beta irradiation; a $4,607 grant to Yerkes Laboratories of Primate Biology to check into behavioral effects of ionizing radiation; a $7,000 grant to Emory University for studies on the influence of oxygen level and temperature on the effects of ionizing radiation, and a $7,931 grant to the Armour Research Foundation, for a wide-range detector and monitoring instrument.

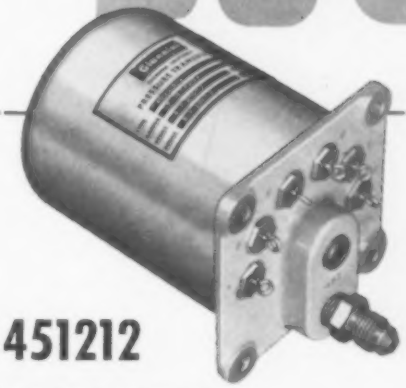
Firms Shift Executives To Aid Missile Manufacture

Organizational changes designed to strengthen firms in the field of service to missile manufacture were announced last week by three major companies.

Biggest re-alignment of executive personnel occurred at the Industrial Products Group of Minneapolis-Honeywell Regulator Co., where four major shifts were announced. George M. Muschamp became group vice president-engineering; O. B. Wilson was named group vice president-marketing; John M. Wilson, formerly head of design and development, became director of engineering; and R. L. Mallory was appointed sales manager.

At Santa Ana, Calif., Giannini Plasmadyne Corp. named A. C. Ducati vice president in charge of development engineering; and at Northrop Aviation, Robert R. Miller and Thomas V. Jones were elected senior vice-presidents, with authority in the fields of general operations and planning.

High Accuracy Mach Information in the DC 8



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Science Academy Sets Up 16-Man Space Board

A 16-man Space Science Board has been created by the National Academy of Sciences to act as focal point for all Academy Research Council space activities. It will coordinate its work with civilian and government agencies and with foreign space science groups.

The board will assess scientific research opportunities in the field and advise agencies and organizations on their space research problems. Dr. Lloyd V. Berkner, chairman of the new board, emphasized that participation of private research institutions and universities would be encouraged.

"While government participation is essential, we feel that it would be unwise if space science were to be developed entirely within the bounds of government activity," he said.

Berkner, who is president of the International Council of Scientific Unions, said the board would work with the council and with other international organizations to prevent contamination of the moon and other planets through earth space vehicles.

The twelve committees, which will operate under the board's direction are: Geochemistry of Space and Exploration of Moon and Planets—Chairman, Dr. Harold C. Urey, Professor of Chemistry, University of California; Astronomy and Radio Astronomy—Chairman, Dr. Leo Goldberg, Department of Astronomy, University of Michigan; Future Vehicular Development—Chairman, Dr. Donald F. Hornig, Professor of Chemistry, Princeton University.

International Relations Field—Chairman, Dr. W. A. Noyes, Dean of the College of Arts & Science, University of Rochester; Immediate Problems (space laboratories, orbits, liaison with IGY)—Chairman, Dr. R. W. Porter, Chairman, USNC IGY Technical Panel on the earth satellite program and consultant General Electric Co.; Space Projects (long range planning)—Chairman, Dr. Bruno B. Rossie, Professor of Physics, Massachusetts Institute of Technology.

Ionosphere—Chairman, A. H. Shapley, physicist, National Bureau of Standards; Physics of Fields and Particles in Space—Chairman, Dr. John A. Simpson, Professor of Physics, University of Chicago; Future Engineering Development Beyond Available Facilities—Chairman, Dr. O. G. Villard, Jr., Professor of Electrical Engineering, Stanford University.

Meteorological Aspects of Satellites and Space Research, U.S. Weather Bureau; Psychological and Biological Research—Chairman, Dr. H. Keffer, Hartline, Biophysics Section, Rocke-

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feller Institute for Medical Research; Geodesy—chairman to be selected.

Dr. Hugh Odishaw, the Academy-Research Council's executive director of the National Committee for the IGY, will also serve as executive director of the new board.

McElroy to Choose Between *Nike-Hercules* or *Bomarc*

A recommendation calling for DOD to choose between *Nike-Hercules* or *Bomarc* was included in Congressional approval of a $1.6 billion military construction authorization bill. In voting 80 to 0 to approve the bill, the Senate went along with a committee reduction of 20% in the combined total fund request for the two missile systems.

The committee allocated the funds for the two systems' launching sites to the Secretary of Defense, instead of to the Army or Air Force, thus handing him the burden of final decision between the two.

Facilities for the *Nike-Hercules*, *Hawk*, and Missile Master control system accounted for $137 million of the Army's total authorization request in construction. About $92 million of the Air Force's funds were slated for *Bomarc* facilities.

Instead of granting the funds to either service, the Senate allotted 20% less than the combined total, or $183,000,000, to the Defense Secretary. He is authorized to construct the missile sites which he deems necessary.

Dutch Firm to Enter Guided Missile Field

Fokker Aircraft is planning to enter into production of guided missiles sometime between 1960 and 1966. F. J. L. Diepen, commercial manager of Fokker, said that the company expects one more generation of manned fighters before air defense becomes the sole domain of guided missiles.

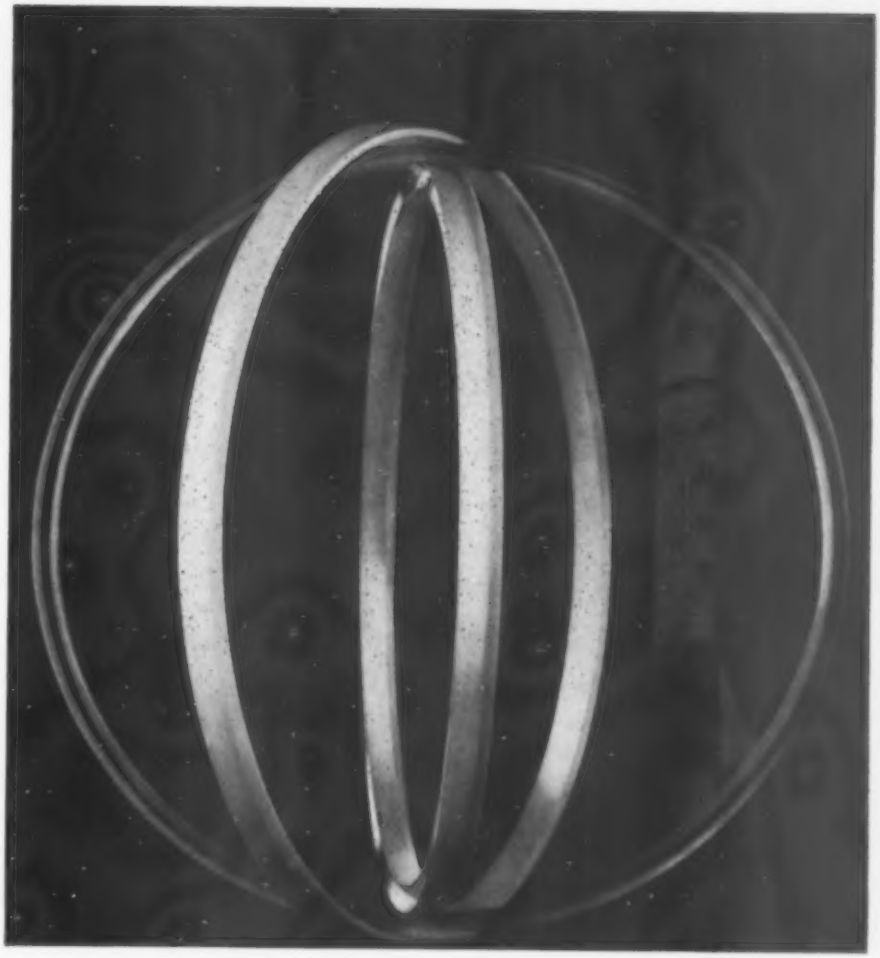
Diepen said it is "unthinkable" that Fokker would undertake development of a new type missile on its own.

Navy OK's Contract For Pyroceram Radomes

A $400,000 contract to the Corning Glass Works will permit the company to add to its facilities for production of Pyroceram missile radomes.

Awarded by the Navy's Bureau of Ordnance, the contract will permit the company to obtain machine tools necessary for finishing the radomes in production quantities.

Pyroceram, a trademark of Corning Glass Works, is a new crystalline material.



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Instrument Buying Session To Be Held in September

A session of special interest to purchasing agents, "How To Buy Instruments and Automatic Controls", will be held during the 13th annual Instrument-Automation Conference and Exhibit, September 14-19 at the Convention Hall in Philadelphia.

The session, to be held September 14 at the Sheraton Hotel, has been planned, according to Dr. Robert Jeffries, president of the Instrument Society of America, to "further professional ethics of buying and selling instrumentation, and to establish a meeting ground and a common language between the manufacturer and the user."

These three areas will be explored: problems of design in original equipment; choosing system for large utilities, refineries or chemical plants; and the special problems a purchasing agent has in buying instruments and control devices.

The Instrument Society of America will sponsor the five-day conference. More than 450 manufacturers of instruments and control equipment are expected to exhibit.

Nike-Hercules Gyros To Be Produced By Telecomputing

New contracts totaling $1.8 million have been received by the Telecomputing Corp., Los Angeles, from the Western Electric Co. for production of gyros to be used in the *Nike-Hercules* ground-to-air missile, it has been announced.

Telecomputing's Whittaker Gyro Division, located in Van Nuys, Calif., will produce both rate and position gyros for the new missile contracts.

Steel Prices Hiked To About $4.50 Per Ton

A new round of price increases is in the works in the steel industry, it has been announced. Six major steel companies—Republic Steel Corp.; Jones & Laughlin Steel Corp.; Armco Steel Corp.; National Steel Corp.; Pittsburgh Steel Co.; and U.S. Steel Corp.—have announced hikes of about $4.50 a ton to an average price of about $150 a ton.

The increases were $3.50 a ton on hot rolled sheets; $4.50 on cold rolled sheets; $3.50 on hot rolled strip; $5.50 on cold rolled strip; and $4.50 on electrozinc-coated sheets.

The companies say a $4.50 per ton boost is designed to offset higher wage costs that have taken effect.

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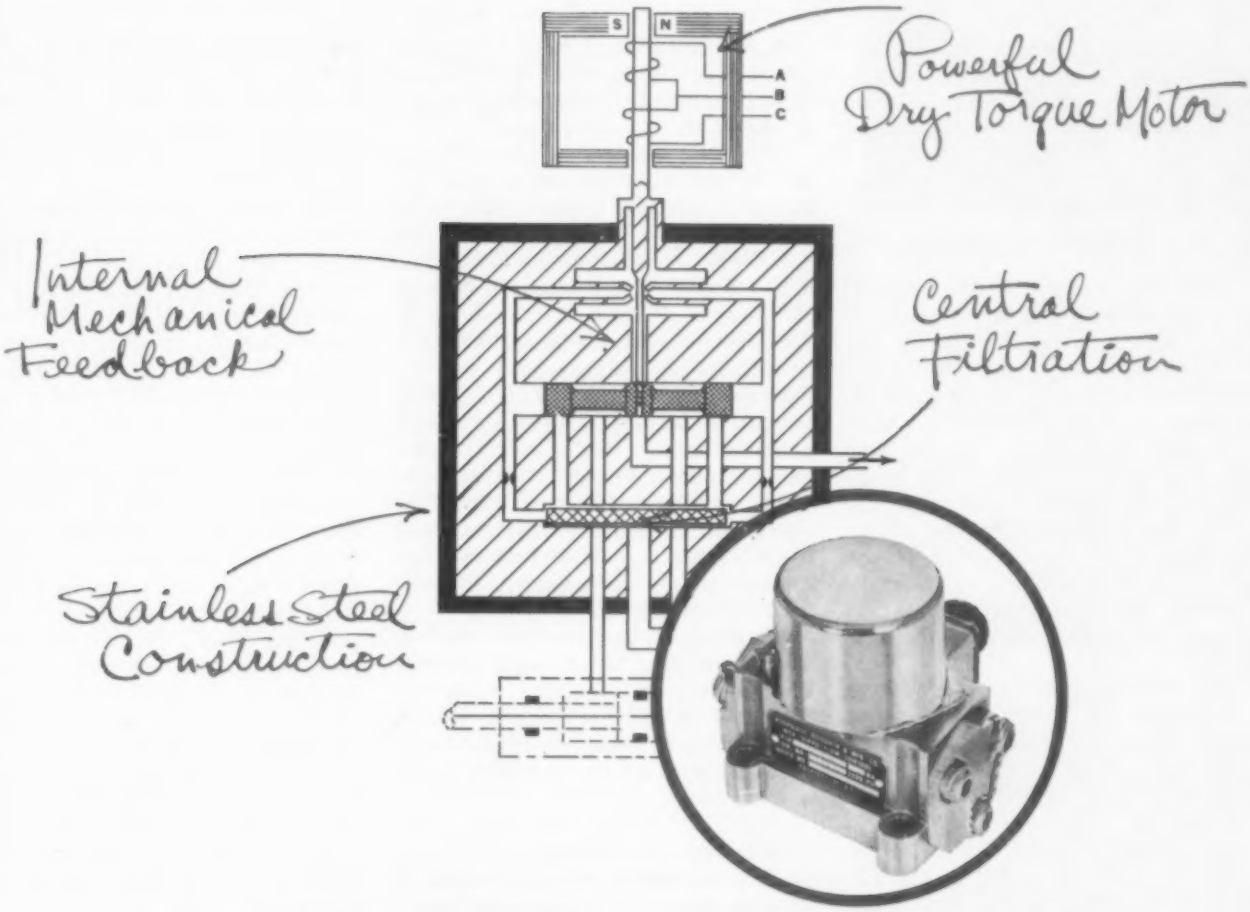

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An m/r special report

Solid Fuels Vie For Propellant Lead

by Alfred J. Zaehringer

SOLID PROPELLANT ROCKETS, now riding high on the crest of increasing missile applications, face a future of competition with liquids and even with itself. The following m/r report covers the most critical areas for future solid rockets: scale-up, production, new materials and supply, and safety.

With the *Polaris* IRBM already under development and the *Minuteman* solid ICBM receiving the green development light, it is evident that a tremendous scale-up is taking place in the design of solid propellant rockets.

Though the *Polaris* missile will vault solid propellants into the long-range (1,500 miles) realm, there is only a slight scale-up in the actual grain. Length of the two-stage prototype is 26.5 feet and the diameter is 54 inches. The same grain mass is being used for both stages of the test vehicles.

The first stage of the test vehicle is a cluster of four *Sergeant*-type rockets, while the second stage will consist of a single rocket. Total propellant mass may only be on the order of 20,000 lbs.

Operational *Polaris* vehicle grain production will represent a major advance in the state of the art. Total launching weight of *Polaris* is expected to be about 30,000 lbs.

• **Major advance**—Though the *Minuteman* ICBM may have a jury-rig set-up in order to get it started, a major manufacturing advance will have taken place. Present plan is to produce a multi-purpose missile.

The top two stages may be quite similar to *Polaris* and could be used by the Air Force as an IRBM replacement for *Thor* and *Jupiter*. All that would have to be developed is a large first-stage booster, which would have a diameter of about 6.5 ft. and a length of about 30 ft. (m/r July 28, p. 50).

The Stage 1 rocket would deliver about 200,000 lb. thrust for 30 sec. Total grain weight would be on the order of 25,000 lb.—a significant step in the fabrication of truly large solid grains. Total weight of the three-stage *Minuteman* would be about 65,000 lb.

It is probable that the propellant will be standard ammonium perchlorate-rubber fuel-binder composite. However, there is the possibility that a slight performance increase may be sought by the inclusion of fuel additives such as aluminum, magnesium, boron, or one of the boron hydrides.

If the solid propellant advocates are able to use these propellant advances, then a considerable improvement in the solid ICBM can be effected. Carrying a 2,000 lb. warhead, the optimum solid ICBM would be only about 50 ft. long, and have a diameter of about 5.5 ft. Total weight would be about 95,000 lb.

Savings in package size—but not weight—would result from a higher propellant loading (90-95%) giving a better mass ratio, possibly higher specific impulse (around 275 sec), and higher combustion temperature. Development of such an optimum solid ICBM would be about half the cost involved in the development of either the *Atlas* or *Titan*.

Production cost would also be lower, but only by a small percent. Very significant savings would be evidenced in the solid ICBM because of negligible handling and maintenance as compared to the complex liquid rockets.

• **Booster breakthrough**—It is quite possible that solid rockets would be used as boosters for space aggregates. However, for launching atomic rockets or ion vehicles, the development of a solid booster delivering about one million lb. thrust would be most valuable.

The solid space booster could be ready in about ten years; based on the advances and scale-up now taking place within the solid propellant industry. Length would be about 70 ft., and diameter about 7.5 ft. Total booster weight might be expected to be 300,-000-500,000 lbs., with a total delivered impulse of 60-70 million lb-sec.

By 1970 *all* terrestrial rockets will be solid propelled. This includes: surface-to-surface, surface-to-air, air-to-air, air-to-ground, medium range artillery, IRBM, ICBM, and possibly even cruise missiles.

Aeronautical applications would include boosters for satellite rockets and space missions, vernier rockets, retrorockets for re-entry vehicles, and possibly boosters for extra-terrestrial planetary escape.

Production of modern solid rocket propellants—whether homogeneous or composite—hinges on machinery know-how and application. Modern solid propellants can no longer be hand-made. Production rates, safety considerations, and quality control specifications are all necessary to assure that solids stay in the rocket race.

Practically all the variables responsible for the success or failure of a solid propellant are now tied to operating characteristics of a particular machine. Thus, hand methods have been thrown out the window as solid composites and homogeneous propellants have finally relegated "powder rockets" to a dying Fourth of July black art status.

This does not mean that the solid propellant business is entirely free of the black art. It has been said that what is not classified is in the trade secret domain. For example, if the Russians were able to obtain secret reports revealing exact propellant compositions, they would still be unable to produce propellants without knowledge of what machinery is being used and how the machinery is utilized.

It is a well known fact that all major solid manufacturers of composites use much the same machines (see table—p. 29)—but how the machine is used is something that only a few people know.

• **Homogeneous first**—The homogeneous propellants (single and double base) first crystallized the need for modern machinery. Reactors and nitrators were needed to produce nitrocellulose, nitroglycerin, and diethyleneglycol dinitrate.

Various techniques were evolved to work these materials into propellants. Standard and specialized mills and mixers were utilized for solvent, plasticizer, stabilizer, and hot working or "colloiding." After standard extrusion or casting, specialized equipment (propellant slicers, inhibitor wrappers, and grain trimmers) had to be evolved.

During World War II, the production rate for rocket solventless double-base propellants was some 20 million pounds per month. Overall, machines produced over 100 million pounds per month of all homogeneous solids (for rockets and guns).

With the trend toward composites, the double-base solid industry today is working far under capacity. In fact, many of the World War II rocket pro-

pellant plants have either fallen into disrepair or have been dismantled. However, some are still being maintained on a R-day basis.

It is estimated that, at the most, some one half to one million pounds per month of double-base rocket propellants are being made. Most of this propellant goes into the small rockets such as *Mighty House, Zuni,* Army artillery rockets, bazookas, recoil-less guns, the *Honest John, Nike* boosters, and the *Deacon* rocket.

All of the homogeneous propellants are being made at government or contractor-operated government arsenals. The machinery is well defined and marked with government specifications. Most of the machinery market today is for composite propellant production.

• **Composites next**—The great break away from gunpowder occurred during World War II when the potassium perchlorate (Aerojet) and ammonium picrate (NDRC) propellants started solids on their rise to flame and glory.

The perchlorates—first the potassium salt and now the ammonium compound—were amenable to machinery control. By coupling these materials with plastic fuel-binders to produce castable propellants an immediate production revolution in solids began to open up.

Standard and readily available machinery could be used. In addition, propellant specifications could be tied to the machinery. For example, oxidizer specifications are given simply as a particular flow rate at a given hammer speed and given screen size with a given puliverizer. This not only makes conditions reproducible, but when scale-uptime comes, the same conditions for the same machine design will generally produce similar results.

Various mixers are used. In most instances, the dispersion blade types are used for the heavier viscosity mixes and the sigma blade types for the so-called castable propellants. Standard units range from laboratory mixers of a few cubic inches working capacity to large mixers with capacities of several hundred gallons.

It is now possible to produce single batches today of one to three tons of composite propellant at a single crack. On a normal shift basis, a 300 gallon mixer might produce some 100 tons of finished propellant in a month. Add several of these mixers, or use a larger one, and it would be possible to turn out enough propellant to fill an IRBM or ICBM.

In addition to propellant mixers there are now required specialized mixers for producing liners, inhibitors, and for pre-processing fuel-binder polymers. Minimum equipment needed to set up a laboratory level composite line would be an oxidizer pulverizer and a mixer—such as the sigma type—the two costing new from one to ten thousand dollars depending whether gram or pound batches are required.

• **Cast or extrude?**—It takes quite a machinery set-up to extrude propellants. However, it pays off in a high production rate and low unit grain cost. Casting is generally cheaper when production runs are short or where the propellant composition must be frequently changed to meet new performance demands.

Machinery and facility investment for extruded solids may be two to ten times greater than for a cast process. Setting up a lab-scale extrusion pilot plant may take $10-$100,000 for a gram or pound grain basis. Despite the scale-up that has taken place in extruded grains, cast composites still lead the race in the ability to produce the largest single grain. The largest extruded grain during World War II was about 500 lbs. It is doubtful if a single grain weighing over 2,000 lbs. has been extruded in the United States to date. On the other hand, it is certain that cast grains of at least 2,000 lbs. were produced five years ago. Today, in the USA and USSR, a single cast grain of at least 5,000 lbs. has been produced. It is believed that it is possible to produce a single cast composite grain of at least 25,000 lbs. (with successive batches) to give grain impulse potentials of about six million lb-sec.

Metals Distn. Corp.
POTASSIUM perchlorate oxidizer.

• **Batch or continuous?**—Considerable interest is developing in continuous mixers for propellant production. The advantages of production in a continuous stream are many. Remote station, automated control is particularly adaptable to continuous mixers.

One of the less desirable features of batch type mixers is the large quantity of material being mixed. And, as the material is being mixed, the potential hazard increases because all conditions for combustion except the spark are present. Should a fire or explosion occur, the smaller the quantity of material in a piece of machinery the better.

For this reason, continuous mixers which have only a small quantity of burnable propellant in them at a given time are of interest. Then, the newer fuel-binders of ten have pot-life limitations which mean critical mixing cycles. And such critical mixing cycles get worse with big batches.

Further, the development of larger size propellant grains has introduced the problem of combining the output of several batch mixers at the right time and still maintaining a uniformly mixed material. However, batch mixers are still the mainstay of the propellant production industry, but considerable development work is going on.

Continuous and automated propellant production will allow high production rates at low cost and at the same time improve quality. Continuous nitrators are already going into operation for the production of double base materials. Coupled with continuous maxing and extrusion, it may be that the homogeneous propellants will be first to operate on a continuous basis.

• **Machinery requirements**—The solid propellant people rely heavily on

Machinery for Solids

Homogeneous		Composite	
1. Reactors	Preparation	1. Dryer	Oxidizer
2. Nitrators		2. Pulverizer	
3. Colloid Mill	Colloiding	3. Sifter	
4. Heavy Duty Mixer		4. Blender	
5. Roll Mill		5. Planetary ("kitchen") Mixer	Fuel-Binder, Liners, Inhibitors
6. Extruder	Grain Production	6. Pony Mixer	
7. Slicer		7. Colloid Mill	
8. Inhibitor Wrapper		8. Roll Mill	
9. Trimmer		9. Dispersion Mixer	
		10. Sigma Mixer	
		11. Muller	Propellant Mixers
		12. Sigma Mixer	
		13. Dispersion Mixer	
		14. Extruder	

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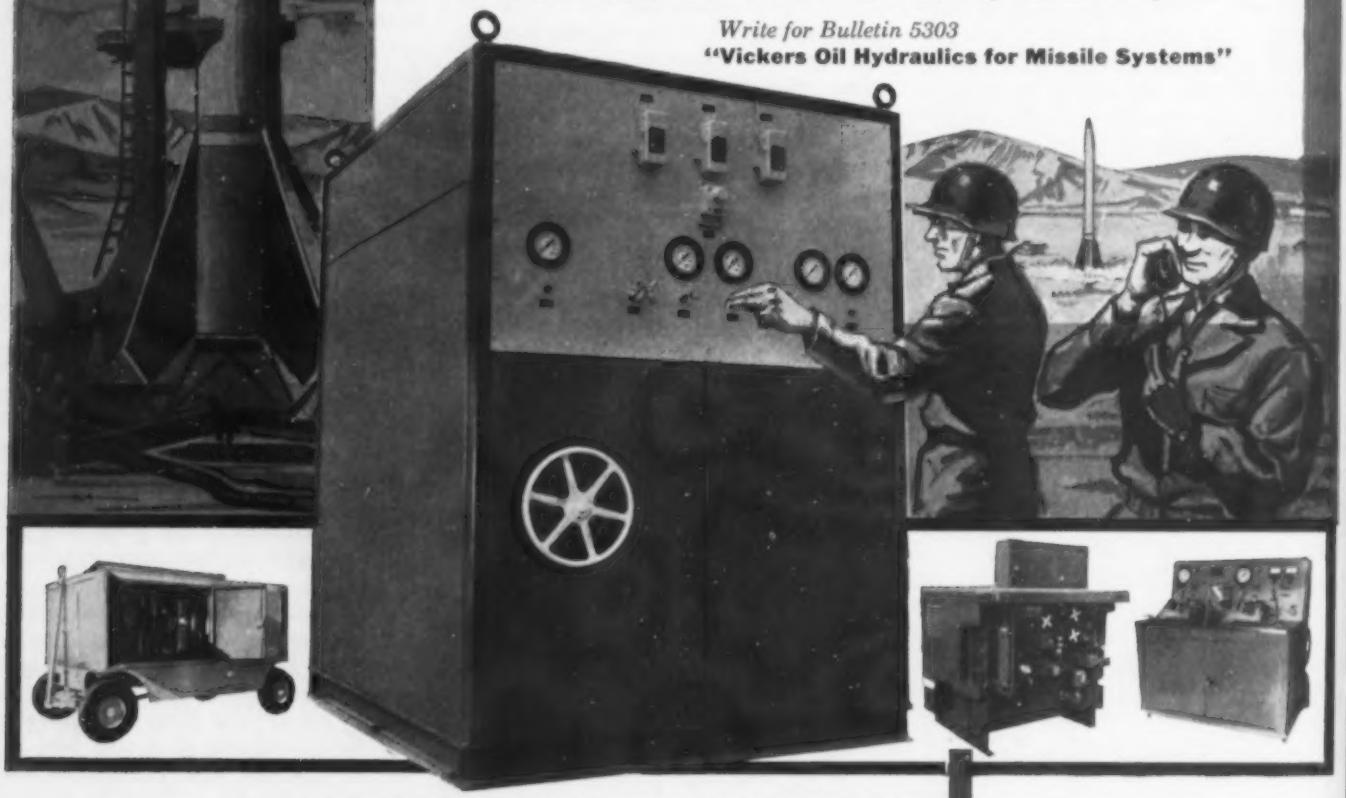

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machinery. As the use of solids increase, the use of machinery will go up. A lab pilot plant may require several thousand dollars worth of just one or two machines. It runs into the hundreds of thousands when you get into actual production equipment.

Most solid propellant process engineers have placed heavy reliance on "pet" equipment. When the scale-up comes it is already written in terms of a particular machine. Therefore, despite the fact that solid propellant production will go up, the machine manufacturers who will benefit will be a rather small, proven lot.

However, there exist other machinery requirements. When you consider the metering, control, and handling equipment associated with propellant production, these total greater than the few basic machines actually used in production.

For the primary production machine manufacturers, it is best to get in with the process engineer on the ground floor—when development is still in lab. That's the way to rise in the solid propellant machinery market.

• **Machinery a key**—Production of ammonium perchlorate, a vital oxidant for high energy solid propellants, will probably be tripled with such missiles as *Nike-Hercules, Nike-Zeus, Sergeant, Pershing* and *Polaris* using the oxidant.

A year ago, there was only one large-scale producer of ammonium percholrate (AP). The Navy's plant at Henderson, Nev., operated by American Potash and Chemical Corp., was producing only 3,600 tons of AP, and about 3,000 tons were going into small rockets.

But the swing to larger solid rockets brought new uses for AP, and early this year the following two new firms entered into production.

HEF, Inc., a combination of Hooker Electrochemical and Foote Mineral Co., will produce AP at Niagara Falls, N.Y.; Tacoma, Wash.; or Montague, Mich. With Foote's lithium background, it is likely that lithium perchlorate also may be produced. However, the immediate need is for AP.

Pennsalt Chemicals has announced that it will produce AP at Tacoma and at another undisclosed site in the South.

In addition to plant dispersal, the new AP plants will tie in better with existing propellant plants—particularly in the Eastern states and South. Those plants that will benefit from the AP supply line will be the Thiokol-RMI complex in New Jersey and Maryland; the Thiokol plants at Redstone Arsenal and Longhorn, Texas; Atlantic Research in Virginia; American Rocket in Michigan; Olin Mathieson and Propellex in Illinois; and possibly Thiokol in Utah.

California supply lines to Aerojet and Grand Central will not be shortened, although it may ease supply and cause price reductions. Other chemical producers are looking at AP. One large concern has been working with a new AP process for some time; another medium-sized electrochemical firm, while not producing perchlorates, has been carrying out an AP R&D program.

• **Capacity increase**—It is not known how much perchlorate will be produced, but a conservative estimate is that production will triple and capacity will be increased tenfold. The late 1959 production rate will probably be 10,000 tons per year, with actual capacity probably 50-100,000 tons per year. This will definitely place AP at the top of the solid propellant production heap.

It will take several years for the next possible solid propellant improvement step—introduction of lithium perchlorate—to catch up with present AP production. But if and when the switch is made to lithium perchlorate, present AP facilities can be used completely or in part to meet expected demands.

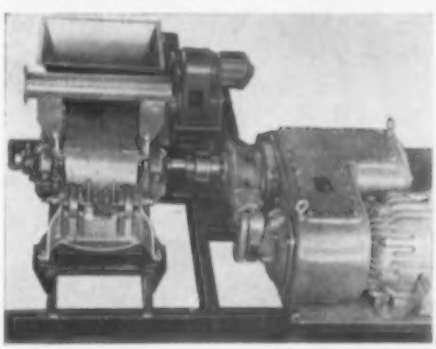
Possibly the Pennsalt plant, and most probably the HEF plant, will be designed as multiple-use or convertible plants for immediate production of AP and eventual production of lithium perchlorate. In either case, until the ozonides or organic solid monopropellants come along, AP will lead the solid field.

• **Missile use**—The following missiles are highly dependant on AP:

Nike-Hercules. The old acid sustainer was replaced by an ammonium perchlorate-polysulfide combination with a burn time of about 30 seconds.

Nike-Zeus. Boost and sustainer both may be slated for AP-polysulfide.

Sergeant. This single-stage solid rocket may use AP-polysulfide.



Atlantic Research Corp.
STANDARD 35 cubic-in. lab mixer unit.

Pershing. This solid replacement for *Redstone* also uses AP.

Polaris. With development well under way, AP is believed to be the oxidant for both Thiokol and Aerojet formulations. Thiokol will probably use polysulfide with high energy additives such as aluminum metal or boron and boron hydride. Aerojet may use its polyurethane with AP and may also resort to high-energy additives.

IRBM. Design studies are probably proceeding assuming AP oxidizer.

Minuteman. The solid ICBM would enormously increase demands for R&D quantities of AP and for production missiles.

Although exact figures outlining AP requirements for missiles may be classified, close estimates have been made. For example, about 10 tons of AP would be needed for a single production surface-to-surface missile of V-2 range and payload capabilities. The actual amount of oxidizer would be about nine tons with perhaps another ton for losses, scrap, small-scale proof testing, physical testing, temperature cycling and long-term storage.

The production figures do not include R&D, which would use many small and full-scale units. USAF asks for about 56 units for full-scale proof or qualification testing; thus using about 600 tons of AP for this phase alone.

Plus figures account for production rockets for training and operational field stockpiles. Training and production requirements could amount to 2,000 tons per year of AP for only one missile. Since only 3,000 tons were produced last year, AP production will have to go up.

• **Lithium perchlorate**—With increasing availability of lithium perchlorate, there is speculation whether it can improve solid propellant performance. Performance undoubtedly can be increased, but the question is—how much and at what price.

Several independent propellant investigators have increased performance of the present 225 seconds specific impulse to over 240 seconds. There are claims that the 270 increase has been reached. However, because of its newness, lithium perchlorate is still in the laboratory league. Whether it gets into the majors is another question.

Laboratory quantities of the salt have been produced by a number of firms—notably Foote Mineral and Lithium Corp. Recently, American Potash & Chemical Corp. started supply.

At present, the salt is made by double decomposition methods, such as the reaction of a basic lithium salt (viz., carbonate or hydroxide) with perchloric acid. This is an expensive and touchy process. It will probably be made by an

electrolytic process similar to the making of ammonium perchlorate. Other production processes are being investigated.

The big advantage of lithium perchlorate is its high density and oxygen availability for combustion. The following table illustrates these features.

Lithium perchlorate supplies more oxygen on a volume or weight basis than either ammonium perchlorate (the present high energy oridant), or ammonium nitrate (a low cost, medium energy oxidant).

Parameter	Lithium Perchlorate	Ammonium Perchlorate	Ammonium Nitrate
Density, lb/ft³	152	122	108
Available oxygen weight %	60.1	34.2	19.5
Melting point F	460	—	340

• **Performance**—On a weight basis, lithium perchlorate has about three times the oxygen content of ammonium nitrate and twice that of ammonium perchlorate. Despite its increased oxygen content, lithium perchlorate is the more stable.

Pure ammonium perchlorate reacts with itself to give a decomposition reaction, and for this reason has no definite melting or decomposition point. This inferior stability of the ammonium perchlorate has caused serious production accidents that possibly will not happen with lithium perchlorate.

The favorable oxygen content, oxygen balance, and stability are all attractive lithium oxidant features. Even combustion temperatures appear to be higher than ammonium salt. Adiabatic flame temperatures for AP propellants range about 3000-4500°F.

However, a disadvantage of lithium perchlorate is that most products would be solids of relatively high molecular weight (see table below) and it is here that performance gains are wiped out.

Product	Molecular Weight	Melting Point, F	Boiling Point, F
Lithium chloride	42.40	1130	2460
Lithium fluoride	25.94	1598	3050
Lithium oxide	29.88	3092	....

The chloride, or in some cases the oxide, would be typical products with lithium perchlorate oxidants and organic fuels. Thus, with completely combustible organic fuels, lithium perchlorate will give a solid exhaust.

The situation (in regard to smoke and high molecular weight exhaust products) would be worse with metals or boron fuels. The table below gives the ballistic performance of lithium perchlorate with various fuels.

Fuel	Wt. % $LiClO_4$ needed for complete combustion	Propellant heat release (BTU/lb)	Specific impulse (sec)	Typical exhaust products
Organic (taken as C_2H_4O)	75	4,500	250	LiCl, CO_2, H_2O
Aluminum	59	5,400	260	LiCl, Al_2O_3
Decaborane	82	5,050	270	LiCl, B_2O_3, H_2O

As illustrated, use of lithium perchlorate would bring near stoichiometric conditions with organic fuel-binders and yet allow good processing conditions. Using a liquid casting resin, a propellant mix containing 75% lithium perchlorate would be castable. The next step would be adding either a metal such as aluminum, magnesium, or boron; or an additive such as solid decaborane.

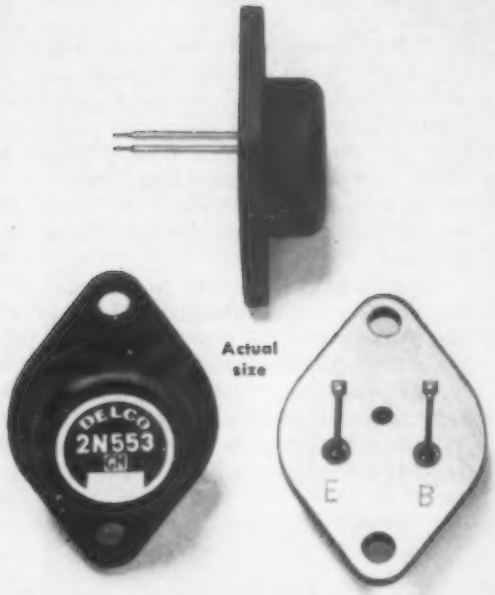
Either technique could yield higher performances over the straight organics and yet allow good processing conditions. With an all-born fuel, it is unlikely that the use of lithium perchlorate would allow solids to attain an impulse of 280 seconds. It should be pointed out that the above table may represent an optimistic outlook.

• **Additional factors**—There are several other factors to consider with this potential oxidant. It is hygroscopic, which would lead to processing difficulties. However, lithium perchlorate would probably be no more hygroscopic than ammonium nitrate and processing under low humidity conditions is an accepted technique.

Cost of the lithium salt is high and availability is low. It is estimated that last year only about one ton was made. Therefore, its cost on a pound basis is measured in dollars per pound. Several

U.S. Navy

EXTRUSION of double base grains requires complete equipment at plant.



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Emitter diode voltage V_{EB} (V_{CB} = −1.5 volts)	40 volts maximum
Collector current	4 amps. maximum
Base Current	1 amp. maximum
Maximum junction temperature	95°C
Minimum junction temperature	−65°C
Collector diode current I_{CO} (V_{CB} = 2 volts)	12 μa
Collector diode current I_{CO} (V_{CB} = −60 volts)	0.5 ma
Collector diode current I_{CO} (V_{CB} = −30 volts, 75°C)	0.5 ma
Current gain (V_{CE} = −2 volts, I_C = 0.5 amp.)	55
Current gain (V_{CE} = 2 volts, I_C = 2 amps.)	25
Saturation voltage V_{EC} (I_B = 220 ma, I_C = 3 amps.)	0.3
Common emitter current amplification cutoff frequency (I_C = 2 amps. V_{EC} = 12 volts)	25 kc
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of the lithium manufacturers are optimistic about cost in large scale production and feel that it could actually compete costwise with ammonium perchlorates.

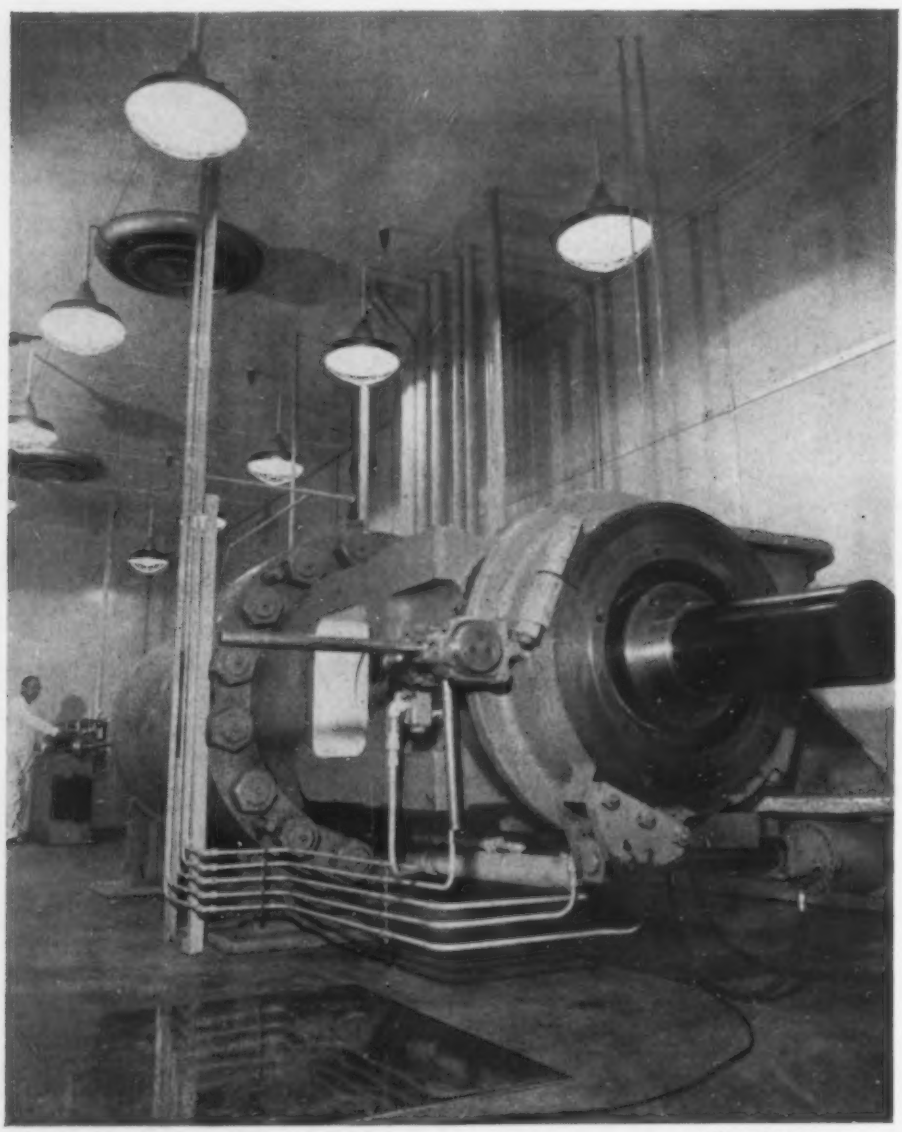
Propellant chemists say lithium perchlorate can give solids an immediate performance increase. Actual amount of this increase is in doubt and probably classified.

Because of molecular weight limitations in the exhaust, it is certain that lithium perchlorate will only put solids in the 250-270 class. Any hopes of nearing 300 seconds will need drastic breakthroughs in preferential or selective oxidation.

It might be possible to selectively oxidize organics to carbon dioxide or monoxide and water and convert the halogen to HC1, keeping lithium at its low molecular weight of 6.94. This will be difficult because of temperatures on the order of 3000°F, 10-100 atmospheres of pressure, and excess oxygen. This illustrates what the solid propellant people are facing to keep up with fluorine or ozone liquid systems.

• **New compounds**—At least two rocket groups are seeking the evolution of new rocket propellants via organic nitrogen compounds. High energy additives for composite and double base solids, and possibly stable liquid monopropellants, could result from the work now in progress at Aerojet and Rohm & Haas.

Aerojet's work seems to be concerned with dinitroethylation—putting the gem-dinitroethyl radical into organic compounds—and winding up polynitroesters and alcohols. This was about all that Aerojet reported at the American Chemical Society meeting in San Francisco in mid-April.



Phillips Petroleum

OPERATOR CONTROLS extrusion of ammonium nitrate grain.

It is believed that the new compounds might have immediate applications in polyurethane fuel-binders where either higher energy content or higher burning rates might result.

Nitrogen also is the key to new synthetic organic monopropellant materials being evolved at Rohm & Haas, Research Division, Redstone Arsenal. The organic group has published a wealth of unclassified material concerning its organic syntheses.

Most of the work is concerned with nitration and nitro compounds. However, recent work with fluorine and the boron hydrides indicate that an entire new class of high energy compounds might result.

Solid propellants, however, may become classless in the future when composites incorporate new monopropellant materials into their mixes and the homogeneous propellant people utilize high energy additives. Aerojet, for example, is already reported to be incorporating aluminum into their composites. Next step will be nitrated plastics. Hercules Powder may resort to adding the borons to their double-base propellants.

According to specialists, only about one ten billionth to one billionth of the mass of chemical fuels disintegrates into energy. Thus, the solid people (and the liquids too), will have to look to new mechanisms of energy release than foolishly seek new compounds. For it is a well known fact that the performance of all known or possible chemical compounds fall within a narrow band in the rocket spectrum.

The rapid scale-up of solid propellant rockets may mean trouble for solid propellants if the concept of "critical diameter" is established. A propellant which normally cannot be detonated might detonate when a certain size is exceeded.

This is a definite danger, according to Dr. John Hyndmann of the Ballistics Section of the Rohm & Haas Co., Redstone Arsenal Research Division. Dr. Hyndmann refers to the general conditions required for transition from normal burning to detonation as set forth by Kistiakowsky during the Third International Symposium on Combustion and Detonation Phenomena.

His proposed mechanism involved ignition of a granular bed of explosive, arranged in order that products of combustion were able or forced to pass through the bed. The resistance to gas flow through the bed results in a pressure build-up and more rapid burning, causing greater flow.

Eventually, the formation of shock waves might be sufficiently intense to become detonative or reactive shocks, and consume the rest of the bed as a detonation. This process has been ob-

served in finely divided beds of double base and composite propellants under test conditions.

It has been concluded that the transition from burning to detonation is a physical condition rather than the chemical make-up of the propellant. Three conditions, usually present in all propellants, are ignition, interconnected porosity, and detonatability.

• **How it works**—Applying the concept of critical diameter to propellants, Dr. Hyndmann illustrates the case thus: materials such as azides and fulminates need less than a millimeter of diameter to detonate. Cast TNT needs about a centimeter. Ammonium nitrate needs about 30 cm.

Thus, the elation some composite manufacturers have concerning the safety of their propellants is a result of having tests conducted with sample diameters under critical conditions.

The Texas City disaster of 1947, where tons of ammonium nitrate first caught fire and then detonated, illustrates the concern that the armed forces have when considering the use of large solid propellant thrust units. Not only the effect on military personnel, but possible effects on the general public, must also be considered.

Ignition is always at hand in a solid propellant, so the other item of concern is porosity. The most likely causes of detonative-inducing porosity are listed as:

1. Shrinking of the fuel-binder during cure (after gel), which results in strained areas at star points and sharp corners.
2. More strain when the propellant cools from cure to room temperature.
3. Separation of oxidizer from fuel-binder, due to wide differences in coefficient of thermal expansion.
4. Separation of oxidizer from fuel-binder because of different coefficient of compressibility when the propellant is pressurized on ignition.
5. Strain on the propellant due to strained metal motor case.

Generally these conditions are more severe at low temperatures and can lead to actual cracks. However in large masses, non-visible strains can also lead to malfunctions.

In order to minimize the probability of the transition from burning to detonation, Dr. Hyndmann suggests that the following measures must be taken:

1. Operate the rocket motor only at a temperature where malfunction is unlikely.

2. Improve the physical properties of the propellant to a point where the strains can be safely tolerated. For homogeneous propellants, this applies to the entire composition from composites to fuel-binders.

3. Bring the propellant up to full pressure more slowly to minimize strain during first firing.

4. Use good design in motor or grain to minimize strain on propellant.

• **Can't hide problem**—Solid propellant advocates will have a hard time in sweeping this critical matter under the liquid-solid race rug. George S. Sutherland of the Boeing Airplane Co., Seattle, Wash., estimates that by 1960 the large scaled-up solid rocket will be over 90% propellant with a rocket weight of about 100,000 lbs.

The solid ICBM, Sutherland figures, will be about 50 tons in weight, and a one-way moon rocket will tip the scales at 280 tons.

Whether the grains are homogeneous or composite, cast, extruded, or cemented, it will mean a large chunk of propellant that could approach the critical diameter needed for detonation. Thus, solids will probably have to be staged at less than optimum conditions to prevent detonations in very large masses.

At a recent guided missile symposium, Standford Research Institute's N. Fishman, R. B. Foster, and I. W. Yabroff presented yet another solid propellant problem—solid propellant aging and missile reliability. Though solids deteriorate at a very slow rate, it can lead to performance variations that are particularly critical in large rockets or for long storage times.

Aging may be a result of many different factors, depending upon the composition of the propellant and its reaction to its storage environment. In most cases, the result of aging is degradation of the polymeric binder-fuel, with indirect effects on the ballistic performance of the system. Elevated temperature, oxidation by storage in air, and reaction with moisture in the air are the most usual causes for changes due to aging. Creep, chemical interchange, or other phenomena, which are inherent characteristics of the propellant binder, may also occur.

All of these considerations indicate that the solid-liquid struggle will continue hot and fast for the next ten years at least.★

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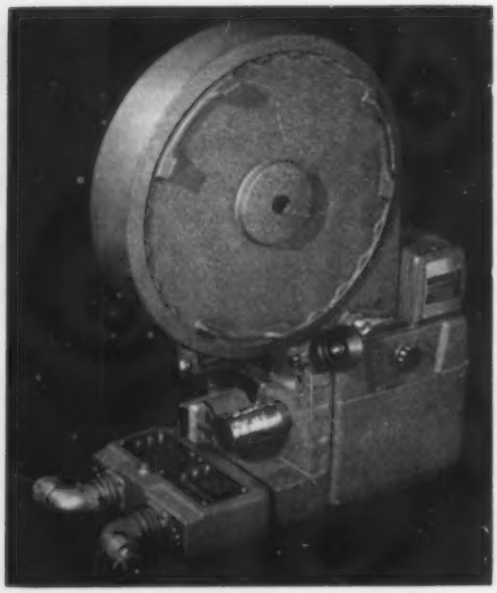


DATASYNC has plug-in amplifier for non-remote use. Footage counter rotates.

DRC-10 control unit for remote use. Color lights show operational mode.

Recorder Offers Speedy Data Processing

by Richard Van Osten

A problem long familiar to test and instrumentation engineers is that of extracting urgently needed data from the complex mass of information gathered during operational evaluation of a system or component.

One device offered as a possible solution to this difficulty is the new DATASYNC recorder developed by Berndt-Bach, Inc., Los Angeles, Calif.

• **Operation**—Currently in use by Convair-Fort Worth and also under study in classified tests at Wright Air Development Center, The Datasync uses standard 16-mm motion picture film that can be pre-striped for as many as ten magnetic sound tracks.

A self-synchronized readout of electrical, visual and audio data is almost immediate within minutes after recording, by use of modern, high-speed, automatic film processing machines.

As the camera takes motion pictures of a missile launching or a high-speed rocket sled run, for example, the film's magnetic tracks are fed instrumentation signals. The feed-in unit, a transistorized multi-channel amplifier, may be remotely located or plugged directly into the camera base.

Amplified and impedance-matched, the signals are fed to recording heads in the camera's film chamber. In a 10-track setup, there are 10 individual recording heads, each equipped with a reproduce head for monitoring the sound track 1/50th of a second after data has been recorded.

Striped for five tracks, the magnetic area can record some 60,000 data bits per second, based on the frequency response of 50 to 12,000 cps. It may also be used to provide a broad-band response from DC to 12,000 cps. Loaded with its present capacity of 1,200 ft. of film, the device can record up to 240 million cycles of analog or digital information synchronized with 48,000 motion picture frames. If properly programmed, a single track may record and readout 300 or more instruments per second.

Regardless of five track or 10 track configuration, a single "balance track" is applied between the film's edge and the perforations. The remaining tracks (four or nine) are laid down between the opposite edge and the film frames. Each track is approximately 0.018-in. wide, and separated from an adjoining track by 0.005 in. The tracks are not affected by the developing process.

• **Use in the field**—Datasync equipment may be adapted to use both magnetic and optical tracks, or both, depending upon the user's requirements.

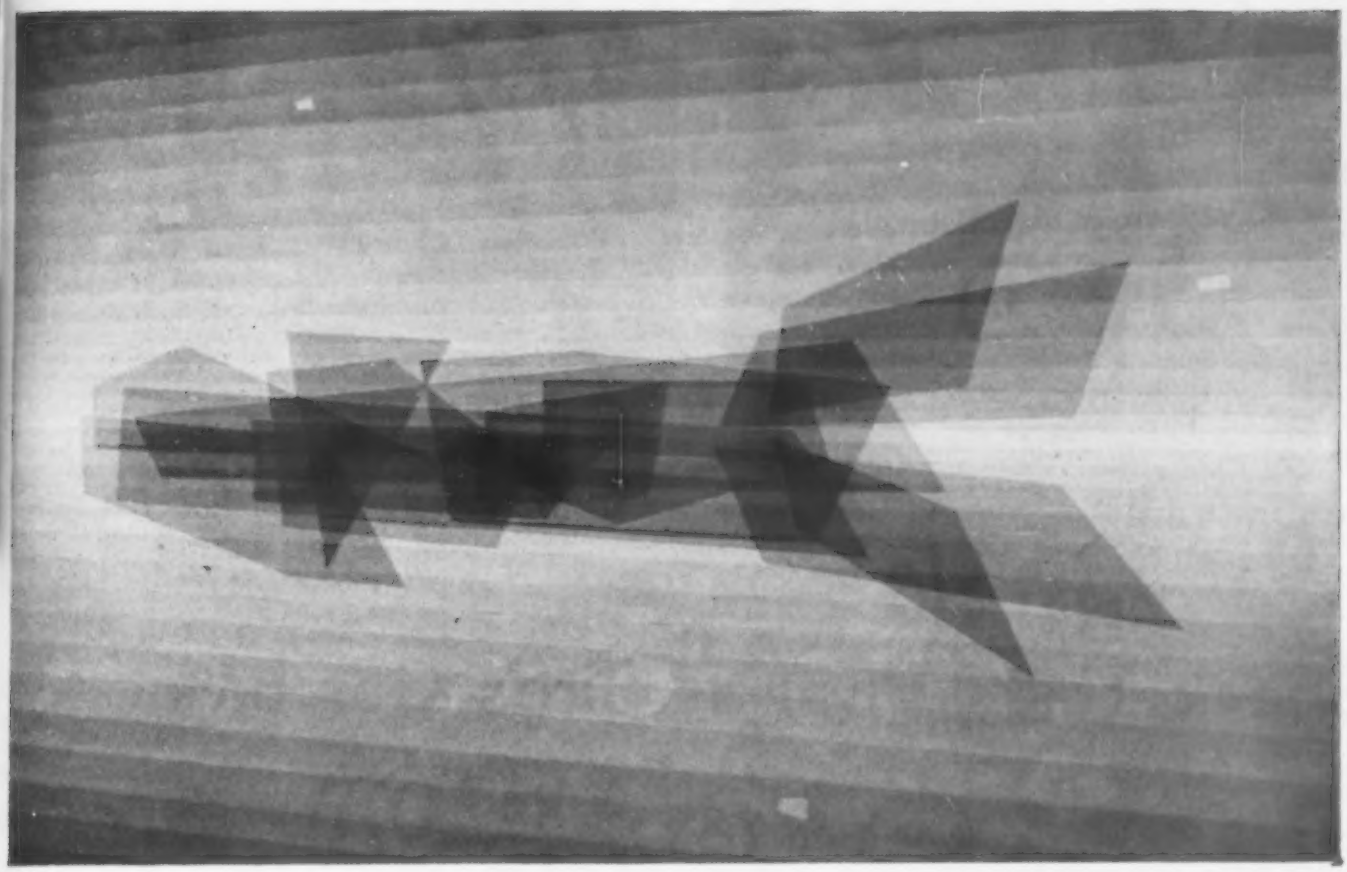
The entire system is comprised of three basic components: the camera; a remote control unit; and the plug-in amplifier for remote use.

The camera, without amplifier, weighs 35 lbs. including the film magazine, and measures 8¼ x 9¾ in. All camera controls, including full frame ground glass focusing, footage counter and plug-in switch unit, are designed for from-the-front operation. This enables the camera to be permanently installed in a corner. Two eye pieces, mounted on either side of the camera, serve as viewfinders and focusing lenses.

The plug-in control panel contains indicator lights to show when the unit is ready to run, focusing, or is running. Neither the "ready to run" nor "running" lights will come on, nor will the camera operate unless: (1) film is correctly threaded (2) film takeup is functioning properly (3) magazine is loaded (4) camera door is closed.

The remote camera control (DAR-10) permits camera operation from a distance of several miles. The same lighting system as in the plug-in control is used in connection with the camera's operational interlocks. This remote control-amplifier package weighs 7 lbs. with two channels. Available with up to 10 channels, the DAR-10 weighs approximately 3.5 lb. per channel.

When remote control is not required, the DAR-10 circuitry is duplicated by a multi-channel, transistorized "chin" amplifier that plugs into the front of the camera base. This unit measures 7 x 7½ x 7½ inches and weighs 7 pounds.



"ROCKETS", one of a series of paintings by Simpson-Middleman, a team of artists with the rare ability to translate scientific fact into creative imagery. Here, the rocket's blast and its guiding beam are thought of as a single stream of light through the center. Darks and lights of definite shape in a weak visual vector field are relied on to suggest the dynamics caused by the acts of the servo-mechanisms in making their adjustments. Painting courtesy John Heller Gallery, Inc.

man in space

Boeing has planned ahead to meet the problems and develop the potentials of the space age—through organizational structure, expanded facilities and advanced fundamental research.

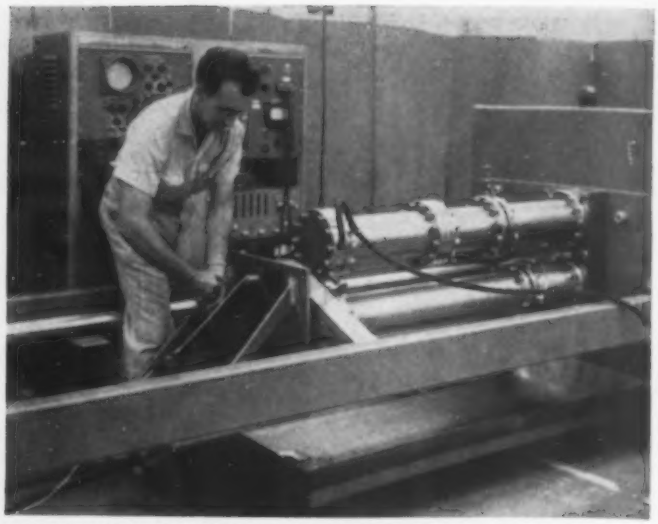
The Boeing Systems Management Office develops proposals and provides management for all projects employing space-age techniques. Advanced studies include boost-glide vehicles, anti-ballistic missile area defense systems, air-to-surface missiles, and manned and unmanned space vehicles.

Boeing's space-age orientation, its tremendous technical and research capability, and its outstanding weapon system management experience earned for the company and its associates an Air Force assignment for Phase I development of Dyna-Soar. This is a weapon system based on a manned boost-glide vehicle that will orbit at speeds approaching 18,000 miles an hour, and be capable of re-entering the atmosphere and making a normal landing.

Dyna-Soar and other space-age projects at Boeing offer exceptional opportunities to engineers of all categories, and to physicists, mathematicians and scientists. Drop a note now to Mr. Stanley M. Little, Dept. R-78, Boeing Airplane Co., Seattle 24, Wash.

BOEING

HYGE SHOCK TESTER demonstration unit. The control cabinet is shown at right, Memo-Scope oscilloscope above.



CONSOLIDATED ELECTRODYNAMICS Hyge Shock Tester in use. Memo-Scope is panel-mounted behind operator.

Shock Tests Vital as Birds Get Bigger

by Raymond M. Nolan

WITH THE RECENT ANNOUNCEMENT that initial contracts had been let for *Minuteman,* (m/r July 28, p. 50) and with the *Polaris* well along in development, environmental testing phases of missile development assumed new importance.

Always a critical factor in testing, environmental factors will be much more stringent with the "second generation" solid-fuel missiles because of vastly increased shock, vibration and acceleration problems.

Probably the most important part of any test program is determining whether or not a missile can withstand the extreme shock, vibration, and temperature variations encountered during flight. The importance of this testing is due to the fact that there is no way to correct for environment-caused errors after the missile has been fired.

Shock is one of the many factors involved, and enters into the missile flight at several stages: firing, separation, firing of additional stages, buffeting of hypersonic travel. It is important to missile designers that the various components be shock-tested during development, and that these shock tests accurately simulate actual conditions for flight. Shock-tests will be even more important in the future, when big missiles will probably be all solid-fueled.

• **Hyge for shock**—At Lockheed's Missile Systems Division, the Hyge Shock Tester, now manufactured by Consolidated Electrodynamics' Rochester division under license to Convair, is used to simulate missile shock conditions. This compact instrument is capable of producing extremely high loads instantaneously, with precise waveform control. High-level thrust loads are transmitted to objects being tested by the instantaneous release of compressed gas acting against a piston.

A Hughes Memo-Scope Oscilloscope and two Consolidated Recording Oscillographs are used as readout and recording instruments. The Memo-Scope retains successive transients at high brightness until intentionally erased, thus permitting leisurely examination.

The Hyge Shock Tester is being used to great advantage on two research missiles—the X-7 and X-17.

According to R. C. Geiger of Lockheed's Missiles System Division, the Hyge is used for shock-testing missile systems and components to high acceleration values simulating booster firing and effection, parachute recovery, and ground landing impacts. The pulse shapes of these shocks are of such intensity and duration that they can cause malfunction or failure of sensitive tubes, relays, switches, gyros.

Even intermittent failures of these components can cause loss of control and destruction of hypersonic vehicles. It is absolutely necessary that all such components be tested completely before use to minimize the possibility of in-flight failures.

The Air Force has found the X-7 to be a thrifty device, since it may be recovered by parachute to fly again. Loaded with electronic gear, the X-7 sends a stream of continuous performance data to the ground by radio while it is in flight. Each re-flight of the needle-nosed missile saves taxpayers $350,000 in missile research costs.

The other Lockheed "test bird," the X-17, is a three-stage ballistic rocket weighing more than six tons and standing as high as a four-story building. Nevertheless, it is inexpensive as compared to full scale operational missiles. This rocket is used to provide information on problems arising when the warhead of a ballistic missile re-enters the earth's atmosphere at high speed.

• **Key links in defense program**—Because these Lockheed test missiles have been described by the Air Force as playing vital roles in the nation's missile development programs, great care has been exercised in securing the best equipment available.

The Hyge Shock Tester has already brought about an improvement in obtaining consistent test results, since shocks can be exactly repeated without the serious variations apparent in sand-box drop tables. The unit has provided a definite improvement in testing techniques.

Prior to installation of the Hyge, all shock testing was accomplished by one of two methods. For shock pulses of five milliseconds or less, a steel hammer with a cast lead nose was used to

strike a pendulum fixture on which the specimen was mounted. The shape and size of the lead nose was varied to obtain the pulse shape, and the height of swing of the hammer controlled the pulse amplitude. This method required replacing the lead slug after every shock.

• **Hyge gives precision**—With Hyge, the wave-shapes, time bases, and levels can be exactly calculated and predicted by means of the metering-pin contours. In many cases, a single metering pin can be used to perform acceleration tests at a wide range of "g" levels with considerable variation in specimen weights, by changing the unit firing pressures and fluid levels.

The output waveform of the acceleration pulse is fed directly from the accelerometer to the Memo-Scope for actual measurement.

To observe an acceleration pulse, a calibrated (Millivolt/G) accelerometer is attached with the test specimen on the Hyge-Shock Tester. With the accelerometer output then fed to the vertical input terminals of the Memo-Scope, and the scope input in millivolts on the screen of the tube, the vertical input of the occurrence will read in G's per square $\frac{(MV\ G)}{(SQ\ MV)}$.

The Memo-Scope horizontal input can be adjusted for sweep time to read milliseconds per square. Firing the Hyge will produce an acceleration-time waveform on the screen which can be read directly. The Memo-Scope tube will store the information for weeks, if necessary. However, a record picture can be taken of the screen for permanent file.

The Hyge Shock Tester has been used to simulate shocks of as high as 200 g's, and shocks of lower amplitude but with a duration of 35 milliseconds. Internal bore diameter is six inches, and rated output thrust is 42,000 lbs.

As it is set up at Lockheed, the Hyge installation includes a control console, actuator, and carriage rail system. The Hyge is mounted horizontally on a large concrete block. Force of the piston propels the carriage, which carries an air brake, along a rail system. Using the rail system to produce low levels of deceleration is advantageous in studying component failures, because the direction and magnitude of deceleration force can be controlled.

• **Oscillographs monitor circuits**—The two Consolidated Electrodynamics Recording Oscillographs, a 14-channel Type 5-116 and a 50-channel Type 5-119, are used to monitor circuits and components of systems under test.★

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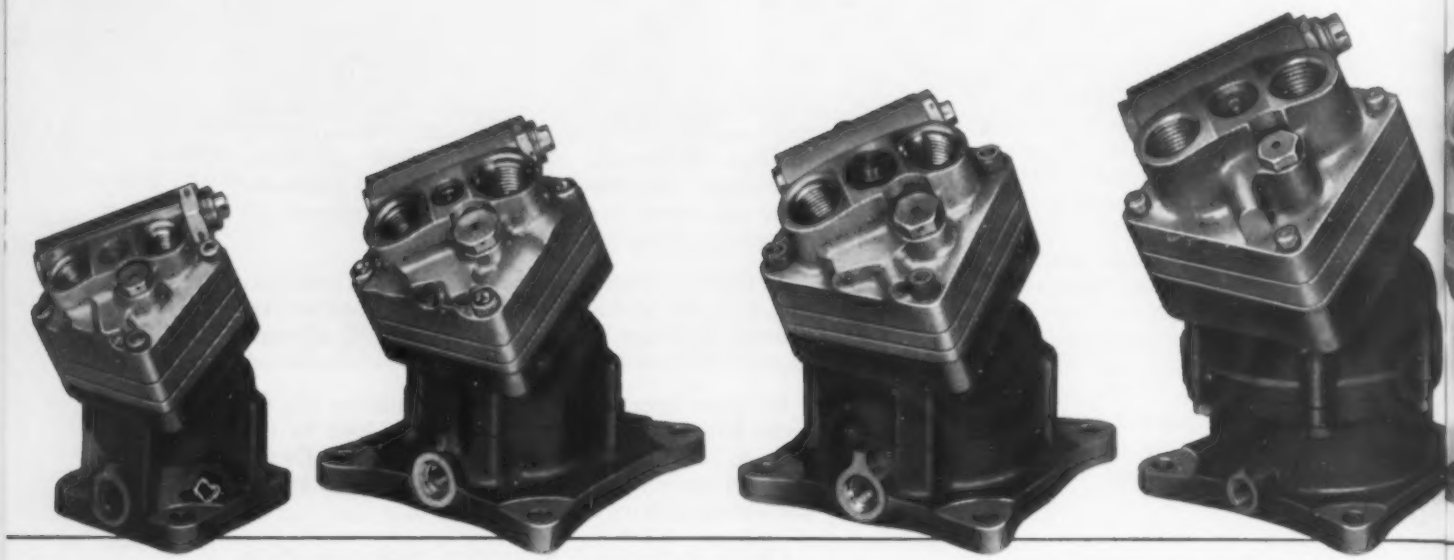
Design breakthrough non

VICKERS. ADVANCED DESIGN

(PV SERIES)



Model Series	PV006	PV012	PV024	PV039
Theoretical Dspl.	.095 cu in./rev	.188 cu in./rev	.367 cu in./rev	.600 cu in./rev
Rated Speed	12,500 rpm	10,000 rpm	8,000 rpm	8,000 rpm
Weight	2.4 lb	4.2 lb	5.9 lb	9.5 lb
Hp/lb @ Rated Speed	3.8	3.4	3.8	3.8
Bolt Spacing	1.875"	3.536"	3.536"	3.536"
Overall Length	4⅜"	5 7/32"	5⅞"	6 13/32"

• "Design breakthrough" as used on this page is a carefully considered statement. Here is the lineup of the PV series fixed angle variable displacement hydraulic pumps for aircraft and missiles systems optimization. The numerous important improvements briefly discussed at the right indicate that these advanced design pumps are destined to set new standards of performance.

All series have integral automatic pressure compensator and a broad range of control methods. This advanced design requires substantially fewer parts than conventional design . . . and it has reduced to a minimum the number of external sealing elements. Now, for the first time, the power saving (and heat rejection) advantages of variable displacement are available in pumps of fixed displacement envelope and weight.

When first announced last March, only the smallest unit (Series PV006) had completed exhaustive endurance tests and was available. Now three more series (PV012, PV024 and PV039) are ready for system application. Three larger sizes are in the development stage. *For further information write for Bulletin A-5233.*

IMPROVED LIFE

Exhaustive endurance tests have proved these new pumps meet the requirement of new MIL-P-19692 specification (i.e., 750 hours at rated rpm which is a very substantial increase over the 560 hours previously required).

INCREASED SPEED CAPABILITIES

The maximum recommended speeds (both continuous and intermittent) have been greatly increased for all sizes without exception . . . more than doubled for some models.

SAME HIGH EFFICIENCY

Volumetric efficiency is from 96% to 98% over a pressure range of 500 to 3000 psi. All the improvements enumerated here have been made without any sacrifice of the exceptionally high efficiency inherent in Vickers axial piston type pumps . . . under partial as well as full flow conditions.

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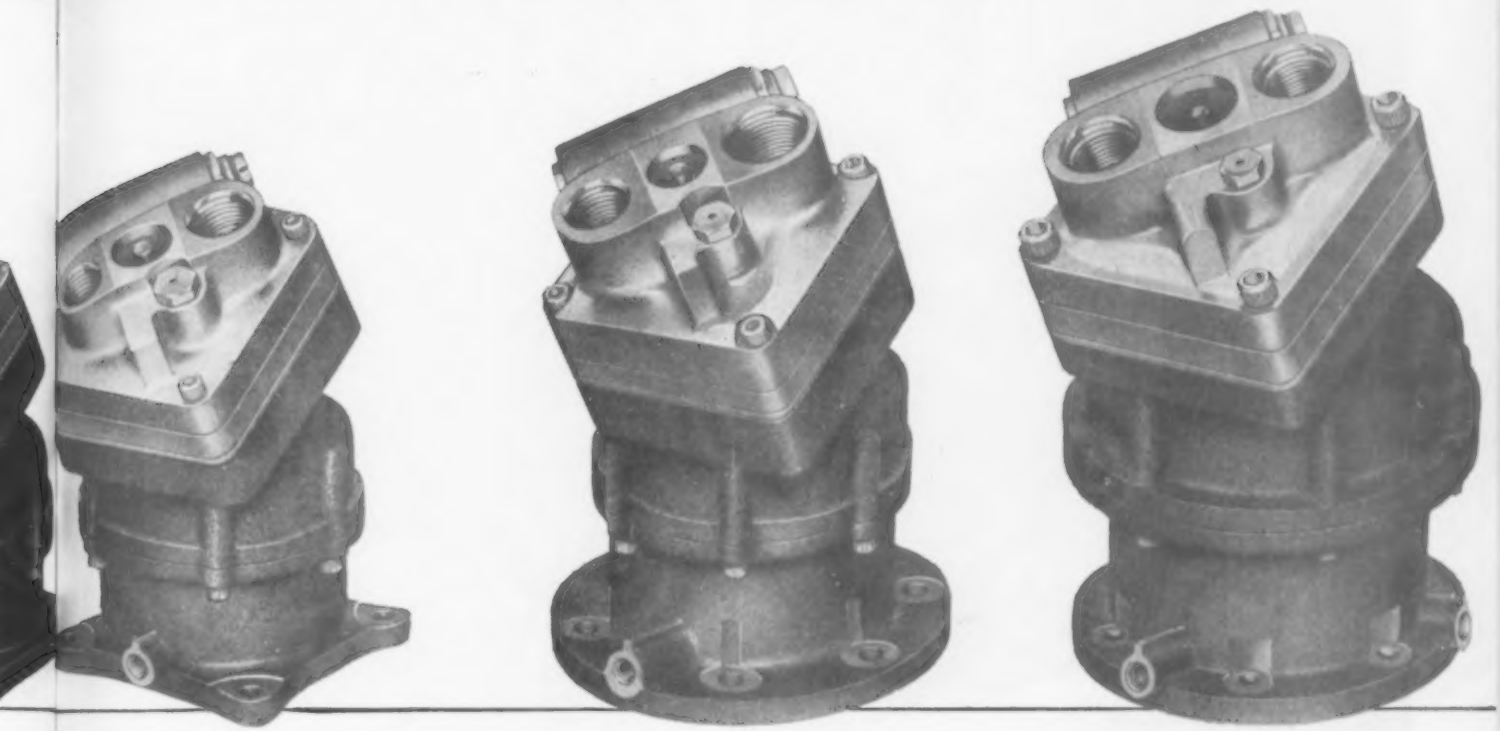
non depth!

ICARIABLE DISPLACEMENT PUMPS



Model Series.....PV062
Theoretical Dspl. .950 cu in./rev
*

Model Series.....PV104
Theoretical Dspl. 1.600 cu in./rev
*

Model Series.....PV153
Theoretical Dspl. 2.350 cu in./rev
*

**Similar inherent performance advancements shown for the smaller pump sizes will be carried over to these models.*

IMPROVED RESPONSE

The PV006 series is capable of full flow to zero flow response in 0.02 sec and zero flow to full flow response in 0.04 sec without pressure oscillation.

MINIMUM PACKAGE

These PV series variable displacement pumps have practically the same envelope as constant displacement units of equal output. In comparison with standard variable pumps, the reduction in envelope varies from 70% to 15% as size increases.

IMPROVED CONTAMINATION RESISTANCE

Performance of these new pumps is greatly improved even when operating with contaminated oil. This improved contamination tolerance results from changes in both design and materials.

IMPORTANT WEIGHT SAVING

The new advanced design pumps represent a 100% increase in power-to-weight ratio over any other variable displacement pumps now available. The magnitude of this improvement is evident from the fact that every added pound of component increases a missile's gross weight from 30 to 75 pounds.

IMPROVED RELIABILITY

Exceptional capabilities (high speed, long life and contamination tolerance) under extreme conditions . . . even greater under normal application.

PARTS STANDARDIZATION

Major parts are interchangeable for fixed and variable displacement pumps and for fixed and variable motors in each series. This standardization results in customer savings.

8118

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STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

In your field, as most of you well know, it's easy to be complicated . . . it's hard to be simple. At Douglas, I'm happy to say, we do things the "hard" way. This matter of simplicity is vitally important. We work intensive hours, days and months to achieve it.

Why this extra effort? Well, simple things work easier, last longer, are more easily maintained and are lots more reliable. We are rewarded for our greater engineering effort with a product that performs better for our various customers.

We know that good engineers, working in an atmosphere which stimulates them to do their best, have been largely responsible for our success. If you enjoy solving challenging problems in the simplest manner, we'd like to talk with you about joining us.

Please write to Mr. C. C. LaVene
Douglas Aircraft Company, Box 620-R
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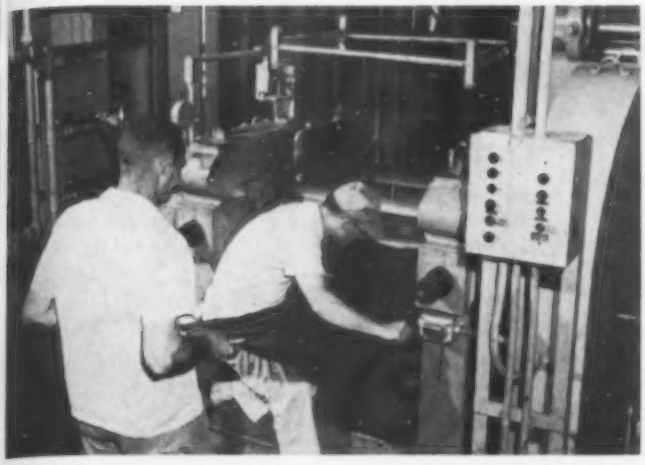
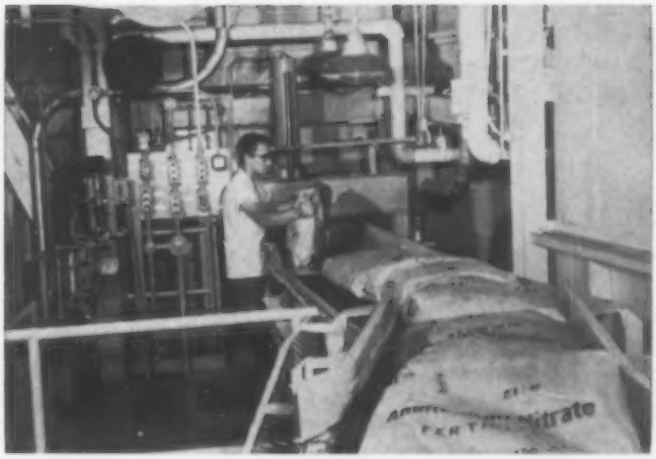


JATO manufacturing—Copolymer is first processed in Banbury mixer. Several lots of copolymer are intermixed to insure uniform viscosity and quality. Carbon black is added to upgrade the material and moisture is removed. Restrictor material is shown as it is pulled from roll mill. Sheets are rolled to thickness varying from 1/32 to 1/8 inch.



Fertilizer grade ammonium nitrate—used as oxidizer—arrives from line storage building by conveyor. Here bags are being opened for preliminary break-up of large lumps. Material will travel upstairs by skip hoist for start of crushing, drying, and grinding operations. Beyond this point, nitrate is processed by remote control in automatic equipment.

Astrodyne Shifts to Cast Grains

Newly-formed Corporation Enters Extensive Modification Program to Compete for Large-Grain Solids Market

by Norman L. Baker

McGregor, Tex.—Astrodyne, the most recently formed corporation in the field of solid propellant research, development and production, is adding to its R&D facilities in an effort to secure a strong competitive position in large cast rocket motors. First step in this direction was a complete reorganization program to assure maximum utilization of personnel and facilities.

The first test of the Astrodyne organization was made recently when the corporation submitted a proposal to the Air Force for research and development on the *Minuteman* ICBM weapon system. Although in the first go-around the Astrodyne proposal was turned down in favor of Aerojet and Thiokol, it has been voiced in some circles that they may be called in later for either R&D or production of the present *Minuteman* concept, or an advanced model of the system.

Astrodyne has more than five years of advanced research and manufacturing experience acquired when it was the Rocket Fuels Division of Phillips Petroleum. A major portion of the production experience has been in the field of small JATO units, with all extensive grain manufacturing using the extrusion process. This is where Astrodyne is currently directing its modification program.

The major difference between cast and extruded grain manufacturing is the final step operation where the grain is formed into its final shape. Propellant grains of the size needed for the *Polaris* and *Minuteman* missiles make it uneconomical and impractical to form them by the extrusion process. Large grain cross sections can be built up from smaller grains, but again this would be time consuming and impractical.

The first casting bell installation was recently completed at the McGregor 12,000 acre site, and construction is underway on new test firing cells. Astrodyne will devote increasing efforts on the development of continuous casting operations, utilizing a wide range of binders particularly suited to ballistic missile applications.

Contract awards have been relatively slow in coming to Astrodyne. Since its formation in February, the company has received $4-million in new research and developments contracts. The company plans to concentrate a major portion of its work in the next few months to research on high energy solids, missile controls and hardware, gas generator charges for auxiliary power units and boosters.

The current contract for production of 1000-lb. JATO units will end in February. The over 100,000-lb. thrust XM-34 booster recently shown boosting a F-100D fighter-bomber from a zero-length launcher is on a limited production schedule.

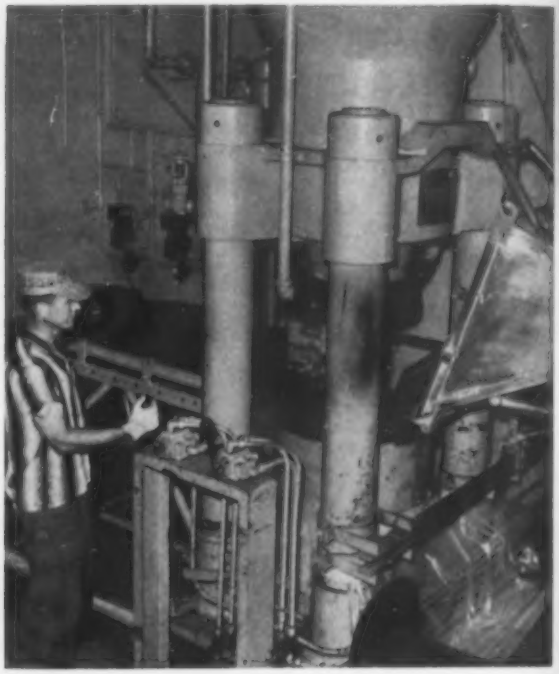
Astrodyne's main propellant and rocket development area includes: 1) a laboratory for conducting bench-scale experimentation on propellants and rockets, 2) an integrated pilot plant with equipment for performing all experimental grinding, blending, mixing, curing, and casting processes for motors of all sizes, and 3) research equipment for studies of new propellant formulations, preparation of solid propellant motors for development test purposes, and pilot manufacturing of new rocket motors and devices.

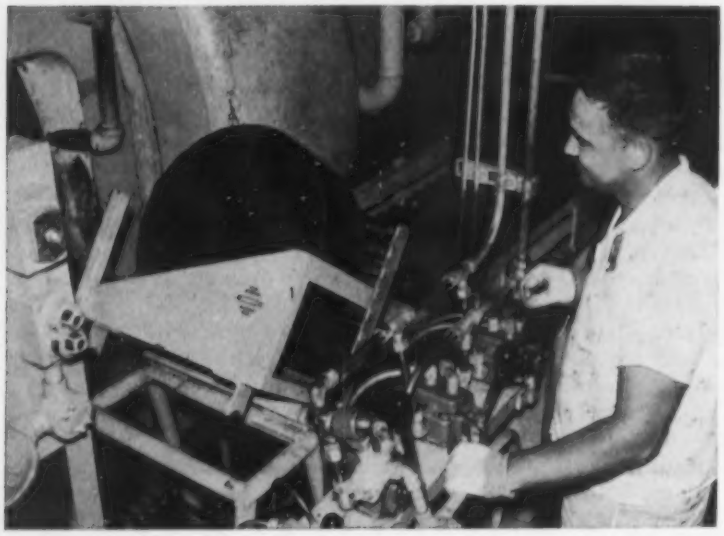
The McGregor production plant has turned out over 130,000 of the 1,000-lb. thrust JATO units. Scientists and engineers now at Astrodyne designed and developed the USAF JATO unit. The grains are made from low-cost, readily available ammonium nitrate—a commercial fertilizer. The cast propellant manufacturing process is almost identical. Major difference is in the mixing and forming stages. Following pages show process.

. . . Astrodyne shifts

Completed ammonium nitrate propellant mix, looking much like soft coal, is scraped from mixer into cart for transporting to blocking press. Mix starts with a slurry paste of rubber and inert ingredients. Oxidizer is added in four equal parts during different stages of mixing. Total operation varies from 45 minutes to several hours.

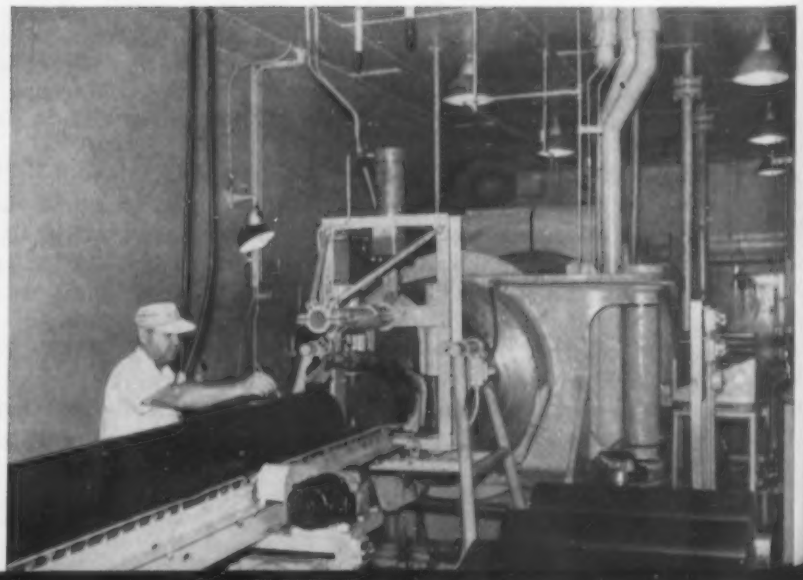
Freshly mixed propellant is carted from mixer and dumped into 490-ton blocking press. Press is operated by remote control after being loaded, automatically pulls a vacuum during early stages of press to eliminate air from propellant mixture. Blocks of propellant are numbered for identification.





Block of propellant is charged to the extruder. After loading of three blocks, extruder is operated by remote control. Machine's barrel is made of chrome hardened steel. Aluminum face plate on ram prevents scratching and excessive friction heat; is coated with silicone grease to facilitate release of propellant from ram after extrusion.

JATO grains emerge from 2,100-ton extrusion press, are numbered for quality control purposes. Press extrudes at rate of nine inches a minute; automatically rough cuts each grain to pre-set length. Astrodyne numbering system permits tracing history of any single JATO unit from the field all the way back to original lots of raw materials going into the mixing formulation.



Operator applies combination of sponge pad and buring restrictor to the grain, clamps on metal corset to hold in place during 24-hour curing process. Automatic lathes have been used to bevel grain ends and trim to finished size. Mandrel with wheels is inserted in center core of grain to facilitate movement through curing oven.

JATO grain and metal case meet for first time at loading station. Here, close-fitting grain is forced into case under 3,500 pounds pressure. Machined steel head is positioned and locked with metal strip key. A rubber O-ring between head and case provides the necessary pressure seal.

Nozzles are added and units are air tested under 10 pounds of pressure as final manufacturing step. Special shipping plug is installed in the igniter opening while the units are being transported to the field. Company name and identification markings are stenciled on case before it is loaded into shipping case.

Finished JATO's are loaded nine to a case for shipment to Air Force bases. A protective cap covers each nozzle and igniters are loaded separately in protective tubes inside the crate. Wooden crates are manufactured by a sub-contractor in McGregor, and are used to transport new JATO cases from a second sub-contractor to the plant.

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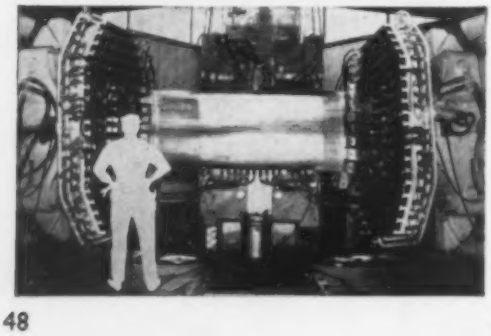

Any doubt in your mind as to titanium's versatility and adaptability for forming and fabrication? Then check these examples from Rohr Aircraft Corporation, Chula Vista, California.

Rohr is a major manufacturer of aircraft parts and airframe components. It uses Mallory-Sharon commercially pure titanium and titanium alloys for many of its forged and fabricated parts . . . takes full advantage of the material's workability, as well as its high strength-to-weight ratio, excellent corrosion resistance and high temperature properties.

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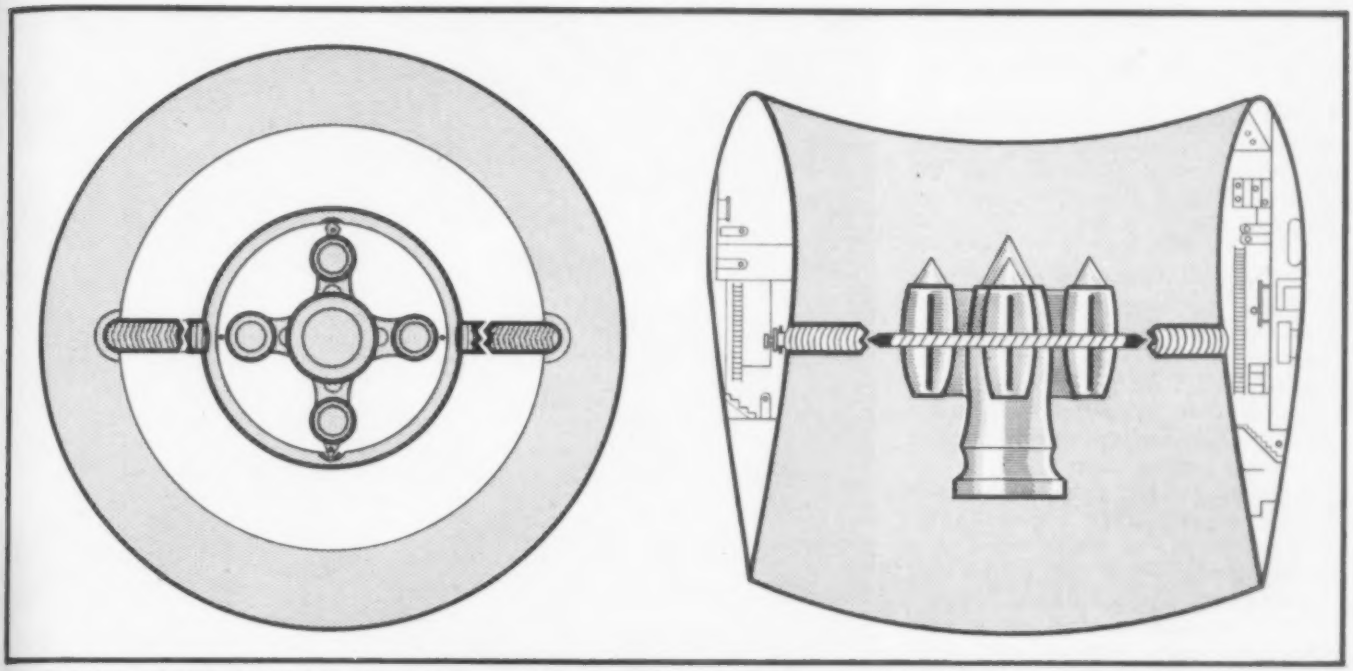

THESE ARE CROSS-SECTION views of a possible approach to economic space flight. Propulsion system is centered and fully gimbaled and includes turbo-jets, ram jets, ion rockets and (for emergency) chemical rockets.

Why Not A Logical Approach to Space Flight?

by W. O. Davis*

THERE IS ANOTHER, vitally important approach to the problem of manned space flight. It is an approach that has been hidden by the pre-occupation of many scientists and engineers with ballistic missile principles.

The approach is Conceptual Design. The principle behind it is as old as engineering itself—visualize the problem first, then design a vehicle that will meet the needs.

For example, a manned mission into space might be divided into six phases; in order to determine what performance will be required of a vehicle, and what characteristics it must have in each of these phases. Logically, the trip could be divided into six parts: takeoff; climb phase below 15,000 ft.; climb phase from 150,000 ft. to orbital speed; cruising; descent and landing.

• **Take-off**—Objective is safe departure from the surface and transition to the climb phase. Essential to this is a highly reliable propulsion system and accurate control.

To insure safety and ease of control, the vehicle's aerodynamic features and propulsion system should be optimum for flight at low speeds and altitudes. Fuel consumption during the first phase should be minimized. The vehicle should not need a large or specially prepared take-off area. Acceleration should be gradual, and so should the change of direction.

• **Climb phase to 150,000 feet**—Safety remains an important, but secondary objective. As the altitude increases, the factors governing safety become more and more an environmental problem. The primary objective of this stage is to gain altitude.

The cost of gaining high speed in the denser portions of the atmosphere is high, and it is best to stay subsonic until entering the higher altitudes. Propulsion and aerodynamics must be optimized for this phase for the rapid acquisition of altitudes. As in take-off, fuel consumption should be held to a minimum.

From the point of view of human factors, acceleration should be kept moderate. As altitude increases, internal temperature and atmosphere must be carefully controlled, to minimize crew's discomfort.

• **Achievement of orbital speed**—At approximately 150,000 feet, air density is no longer a problem, and the primary objective is to obtain orbital speed. The ability to control minor motions becomes less urgent. The atmosphere should be used as a working fluid as long as possible to minimize take-off weight. Acceleration and radical changes in direction must still be kept moderate for crew safety.

• **Cruise**—The cruise phase involves flight completely outside of the earth's atmosphere. Now we want distance. And, the need to return to base with sufficient fuel lift for a successful landing. Space flight implies design which incorporates the lowest possible mass ratio. Safety is important, but at this phase it centers largely around the factors of human environment. Can we depend on our simulated internal atmosphere, radiation insulation, and can we avoid objects in space? Travelling great distances in space calls for a simple, reliable propulsion system. Great speed is required, thus a continuous low rate of acceleration is needed.

An optimum balance must be achieved between the amount of fuel carried to permit continuous acceleration and a short trip; or a high payload weight of stores to sustain the crew for a long period of time and a slower trip. It may prove desirable to accentuate fuel capacity and consumption to limit missions to days, rather than to fly trajectories which would extend the mission to months or years at minimum energy.

• **Return to earth**—The vehicle will initially follow an orbital track. The first element of the descent phase is to reduce speed to insure safe re-entry into the earth's atmosphere. Design criteria must include rapid heat

**Formerly Deputy Commander for Operations AFOSR, ARDC.*

dissipation and thermal protection for the crew. Control resumes its initial importance as the vehicle nears landing.

• **Landing**—An integral part of this objective is close directional control, low rates of deceleration, and the ability to land in a small, relatively unprepared area.

• **Design**—With these requirements in mind, the total design of the vehicle must incorporate economy of construction and operation. These factors, coupled with a reasonable payload, are essential if we are to perform useful military or commercial tasks. The ideal is a single configuration.

Assuming that certain technical capabilities have been achieved prior to construction, we might arrive at a design configuration similar to that depicted here (see drawing).

The annular air foil has a high strength-to-weight ratio and good aerodynamic qualities during take-off, landing, and both high and low speed flight. It is also well suited to central location of several different propulsion systems.

The large surrounding cylindrical area has exterior wall surface that can become a floor during the cruise phase of the trip. (At this point in the journey, it may be necessary to rotate the vehicle about its central axis in order to simulate gravity by use of centrifugal force.)

During the take-off phase, the vehicle would be propelled by large turbo-jet engines, operated by either chemical or nuclear heat. During take-off, solid propellant rockets might be added, as stand-by power in case of failure of one of the turbo-jets. In this event, control would presumably be provided by balancing the thrust of the remaining jet engines.

As the entire propulsion system is hung in gimbal mounts, control can be achieved by tilting the power plant or inverting it on its horizontal axis to provide reverse thrust for slow-down during the landing or re-entry phase.

• **Propulsion system**—The main propulsion unit might be a large ram-jet engine surrounded by the auxiliary turbo-jets. The ram-jet engine would have a nuclear heat input and would be activated as soon as optimum speed and altitude are reached. On attaining an altitude of 150,000 feet, some means of electromagnetically accelerating particles of ionized atmospheric constituents would gradually be introduced, thereby making use of the magneto-hydrodynamic properties of ionized gases.

As the flight progresses into the ionosphere and the density of the atmosphere decreases, the electromagnetic propulsion system will be of increasing importance.

A VIEW of Col. Davis' "conceptual design" as it might appear in flight past the moon. It is operating on its ion propulsion system, having first reached orbital velocity by means of turbo-jets and ramjets.

In this phase, despite the use of electromagnetic propulsion, acceleration of the vehicle will decrease. As orbital speed is achieved, however, the degree of acceleration becomes less important. At the top of the atmosphere density approaches zero, and it is necessary to introduce a source of ions into the propulsion system. For the first time, a working fluid will have to be used, though it may be supplemented to a small extent by ionized particles that occur naturally in space.

During the cruise, a combination of ion source and electromagnetic propulsion will provide a continuous but low acceleration, perhaps of the order of 1/1000 to 1/100 of an earth gravity. Rotation of the vehicle about its axis will be achieved by deflection of part of the exhaust stream, and artificial gravity achieved.

In the event that astronomical observation is required, the vehicle can be momentarily brought to rest and suitably stabilized. The ability to provide a constant but low factor of acceleration would permit a degree of maneuverability which will greatly simplify navigation.

• **Descent**—During the descent to earth, the electromagnetic propulsion system can be reversed and the kinetic energy of the vehicle converted into stored electricity, or dissipated as heat within controlled limits.

In this manner, the majority of the vehicle's kinetic energy should be dissipated before entering the lower layers of the atmosphere.

At an altitude where charged particles are no longer available, the ram jet can again become operational and, for the final landing, control can be gained by starting the turbo-jets.★

Soviets Discuss Satellite Crew Recovery

by Frank G. McGuire

A Stalin Prize winner, P. Isakov, has authored an article in the Soviet Army newspaper, RED STAR, on "The Problem of Returning Satellite Crews from the Cosmos."

Isakov has reduced the means of accomplishing the safe return of satellite crews to two possibilities: return of the satellite as an entire unit, and return of the crew only. According to the article, the second of these is the easier and most practicable method.

Ejection apparatus and hermetically-sealed capsules may be used for catapulting crews from rockets or satellites which have been slowed by use of retro rockets or braking ellipses. Isakov maintains that if the velocity of the satellite vehicle can be successfully lowered to the desired degree, the ejection of its crew can be accomplished by methods already in use in aviation.

The practical development of such a method, however, is still needed in obtaining supplementary data. Most important is the need to acquire sufficient temperature-rise data during different braking intensities, on cooling the satellite under different conditions, and other situations.

High-temperature effects on crew members is also being sought, according to the Soviet author, and the development of protective clothing and other equipment is a must. At present, he says, man is in a position to withstand surrounding temperature increases up to and over 100°C for short periods.

Clothing of special types has already been developed which permit a man to remain in a temperature of 300°C. He mentions, however, that this clothing was developed in "other countries" than the Soviet Union.

Acceleration and deceleration problems are also under study, Isakov says, and states that "it has been established that man can withstand a force of 3 — 5 g's for short periods with no harmful after effects." But he notes that continued acceleration or deceleration to this extent results in serious change in a man's condition which sharply limit his efficiency.

• **Italian experiments**—Isakov mentions the experiments of Italian scientists who subjected animals to g forces while the animals were submerged in water. Such a method, he notes, was suggested during Tsiolkovsky's time. The present experiments showed that under these conditions animals could withstand much higher g-loads than under normal conditions.

Excessive rotation was also listed by the author as a dangerous phenomena. Rapid and irregular rotation of the body in all planes can cause serious effects such as complete unconsciousness if a speed of 2-3 revolutions per second were experienced over a period of 10 to 15 seconds. In an ejected-capsule-type recovery of a crew from a manned satellite, this rotational factor would be a prime consideration unless a positive control on rotation were included in the equipment, as it undoubtedly would be.

Live animals ejections from high-altitude rocket flights have been reported for some time by the Soviet Union, apparently in efforts to solve some of the problems covered by Isakov's article. Results of the experiments are reported to have been highly successful in proving that survival was indeed possible in extreme-altitude ejections, even though the vehicle was not travelling at orbital velocity.

• **Another technical article** in a Soviet magazine, by G. I. Pokrovsky, discusses the possible natural forces in

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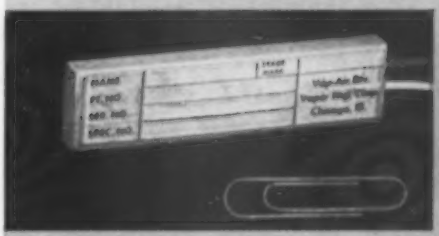

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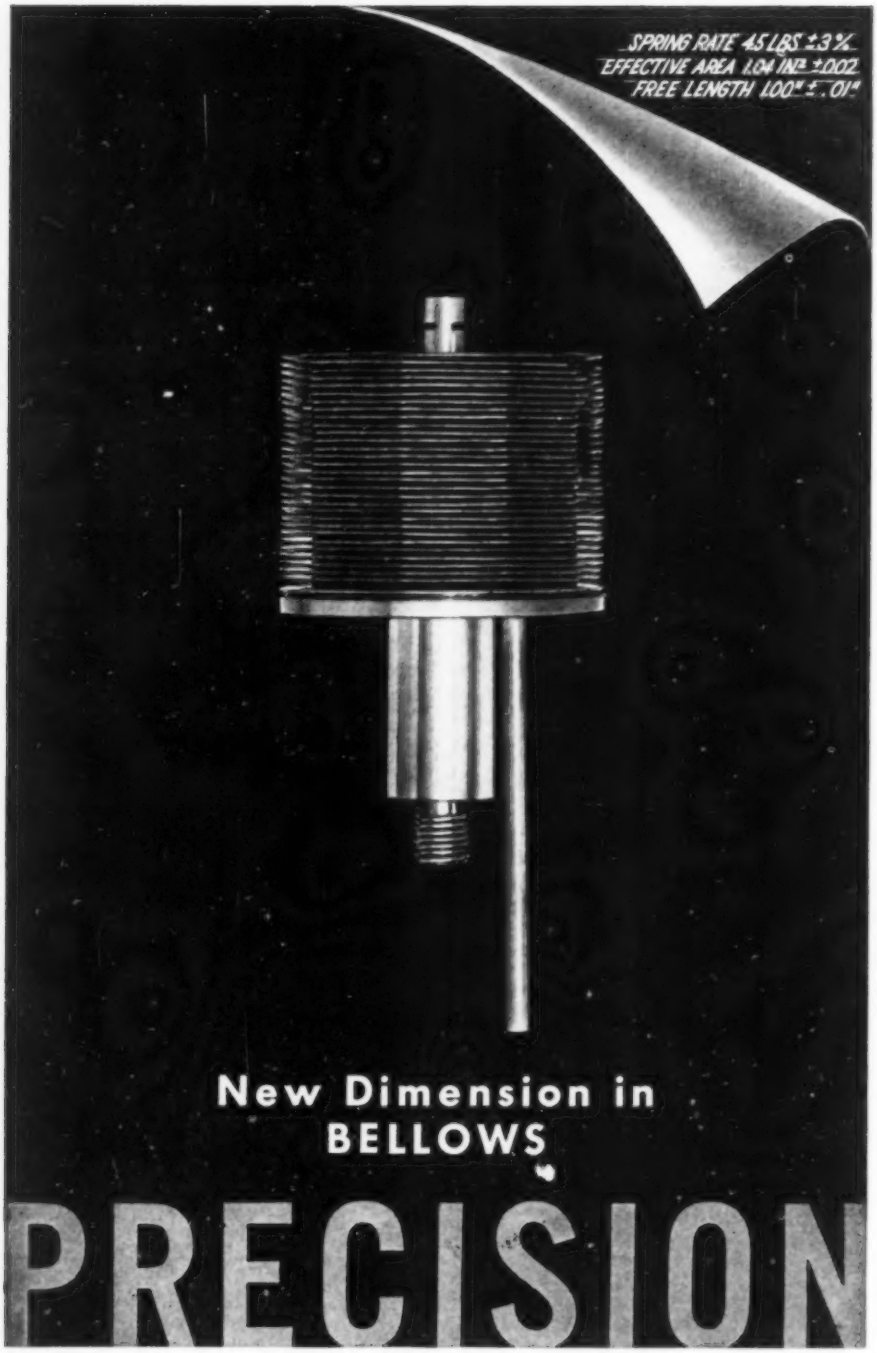

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. . . Soviet recovery

space which could be used to pro a space vehicle. The author of article suggests that "cosmic elec magnetic fields" be used for cont able power. The author also states the elements of the equipment nec to utilize this power have already designed for other applications.

According to Pokrovsky, two part accelerators comprise the basic elem of this equipment. One is intended the acceleration of positively-charg particle, hydrogen ions; the other for the acceleration of the negativel charged electrons.

If the first accelerator is in opera tion, a positive charge leaves the space ship and the whole ship negatively charged. If the ship is lo cated in a cosmic electric field, it will move toward the positive pole. Simi larly, if the electron accelerator operating, the ship will move toward the negative pole.

By changing the sign and magni tude of the charge, the cosmic ship can change acceleration and direction. Protons and electrons must be emitted from the ship at sufficient velocity to prevent their falling back on the ship.

The forces arising from this method will not be very large in most cases, Pokrovsky asserts, but considering the extent of outer space and the possibility of prolonged acceleration, one can imagine that electromagnetic fields in space can be utilized to great extent.

Varian Sales Reach All Time High

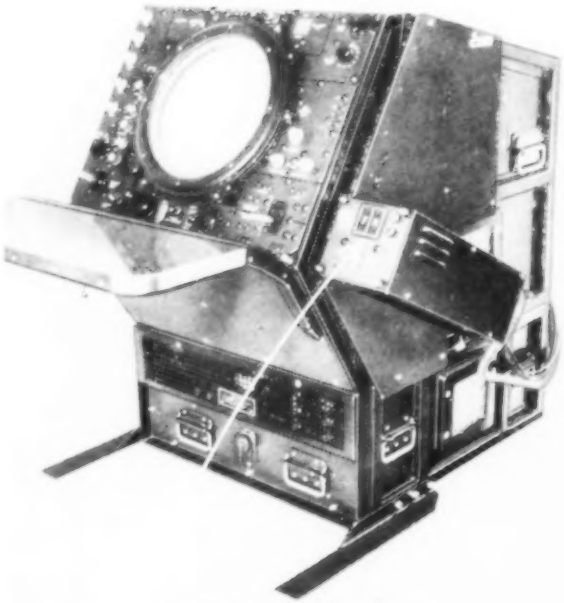
Sales of Varian Associates, Palo Alto, reached an all time high, ac cording to the firm's third quarterly report to stockholders. Third quarter earnings per share are shown as 25¢ compared to 12¢ and 18¢ for the first and second quarters, bringing the elec tronics firm's nine months earnings to date to 55¢ a share.

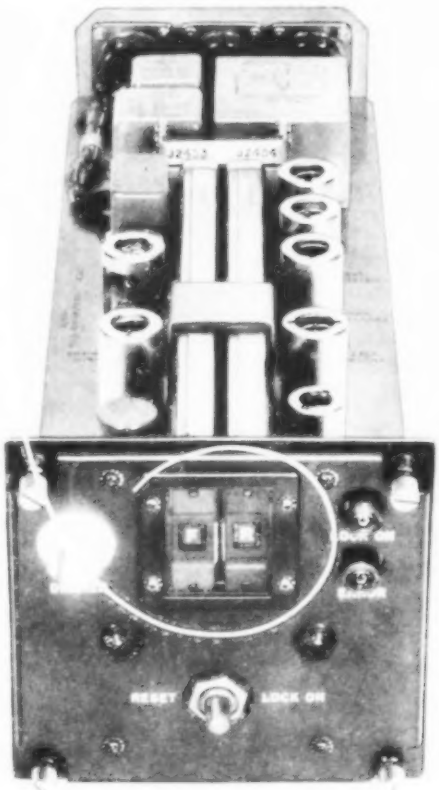
In May, Dr. Louis Malter, who was chief engineer of the Semi conductor and Material Division of RCA and formerly assistant director of their electronics research laboratory at Princeton, N.J., assumed the post of director of research for Varian.

Company-sponsored research and development is up 24% over last year and the combined value of com sponsored programs and engine effort carried out for customers is $3,815,653 for the first nine months of the year.

President H. Myrl Stearns says that the company expects to main its present level of sales and earn during the fourth quarter.

Union Indicators help Hazeltine radar-display unit identify aircraft





Just a glance at the little black box on the right side of this radar-display unit tells the operator whether an approaching aircraft is friend or foe. The IFF response is processed by radar equipment and is displayed in the Hazeltine unit by Alpha-Numerical Indicators manufactured by Union Switch & Signal. The radar-display unit is manufactured by Hazeltine Electronics Division of Hazeltine Corporation, Little Neck, New York. Hazeltine chose Union Switch & Signal's Alpha-Numerical Indicators because of their compact design and supreme reliability, and for the features listed below.

Two Types — Union Switch & Signal makes two types of Data Display Indicators: Digital types, displaying 10, 12, or 16 characters on a wheel, and Alpha-Numerical types, displaying up to 64 characters on a Mylar belt. Character assignments can be furnished as required.

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Electrical Read-Out — The design of the decoding and control portion of the Indicators inherently provides electrical read-out of data in the same form as the input. The data can be read out of the Indicators on a continuous basis or as often as desired without erasing the stored information.

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world astronautics

by Frederick C. Durant III

Two Japanese societies will be represented at the IX Congress of the International Astronautical Federation (IAF) at Amsterdam, August 25-30. JAS President Mitsuo Harada writes that Masatoshi Tomioka, a science editor of the YOMIURI SHIMBUN newspaper chain, has been appointed delegate for the Japan Astronautical Society (JAS). Tomioka is a director of the JAS. Since the JAS became an IAF member in 1955, your columnist has had the privilege of holding proxy and serving as the Japanese delegate at the annual congresses.

In addition to the JAS, which is devoted primarily to astronautics, the Japan Rocket Society (JRS) will apply for IAF membership this year. Dr. Hideo Itokawa, leader of the Japanese IGY rocket research, expects to personally present the JRS application at Amsterdam.

Back from a junket to Moscow, IAF President Andrew G. Haley brings the news that the 1959 IAF Congress will probably not be held in the U.S.S.R. IAF Vice-President, L. I. Sedov, has evidently run into a snag in obtaining official approval for the event. The alternate 1959 meeting place, put forward by The British Interplanetary Society, is London. A bid for Stockholm as site of the 1960 IAF Congress has been made by the Swedish Interplanetary Society.

Vol. I, no. 1 of ASTRONAUTIK, technical journal of the Svenska Interplanetariska Sälskapet (SIS), has just appeared. A 52-page, well printed publication, ASTRONAUTIK will serve to disseminate details of space flight to Swedish scientific and technical circles. A membership list recently received, reveals that the SIS now has more than 200 members, a high percentage of whom are professional engineers or scientists.

Because of frequent requests for names and addresses of foreign rocket and space flight societies, column readers may obtain a copy from: 35 Lowell Road, Concord, Mass. Many readers are interested in astronautical publications in foreign languages, and a friendly welcome is assured anyone visiting the home offices of IAF member organizations in the 21 countries represented. Those anticipating travel abroad should write in advance concerning probable date of visit.

Erich Dolezal, vice-president of the Oesterreiche Gesellschaft für Weltraumforschung, Vienna, has just completed a two-month tour of the U.S. Sponsored by the American Council on Education, engineer Dolezal visited major rocket facilities and astronomical observatories coast to coast. He is editor of an Austrian science journal.

R. Jastrow and S. I. Harris of Naval Research Lab have published the study results of the fall of *Sputnik* I rocket body (Alpha I). It will be recalled that last December, the U.S.S.R. Academy of Sciences made allegations that remnants of the rocket body had fallen in Alaska and the U.S. Northwest. The Jastrow and Harris paper, using calculations based upon U.S. and U.K. radar observations, concludes that the rocket fell in Outer Mongolia on December 1. Last known observation was made by the Royal Radar Establishment, Great Britain, at an altitude of only 71 miles.

Three methods of tracking satellites have been used now: optical tracking, reception and triangulation of satellite-transmitted radio signals of various frequency, including the NRL minitrack system and radar reflection. The use of radar for tracking satellites was not planned by the U.S. because the size of the anticipated IGY satellite was too small. The Russian satellites, however, were above the threshold required to bounce back a receivable signal.

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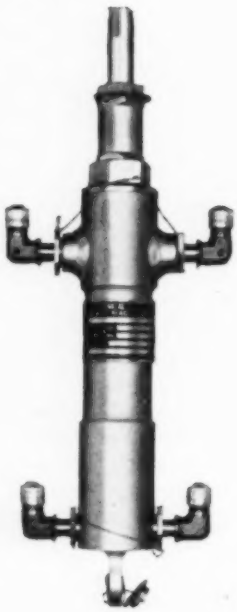

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books

METALS FOR SUPERSONIC AIRCRAFT AND MISSILES, The American Society for Metals, Cleveland, Ohio, 423 pp., $7.50.

This is felt to be one of the most complete studies offered on the subject of metallurgical problems being encountered today.

Contents of the book include technical papers written by 22 authors and presented at the Conference on "Heat Tolerant Metals for Aerodynamic Applications" held last year. The conference was held under the joint sponsorship of the University of New Mexico, Albuquerque; and the Albuquerque and Los Alamos chapters of the American Society of Metals.

This study spotlights the phenomenon of the so-called "Thermal Thicket," wherein supersonic velocities result in increased temperatures of structures flying at those speeds.

NONLINEAR CONTROL SYSTEMS by Robert L. Cosgriff, 328 pp., $9, McGraw-Hill, New York

This book is another in McGraw-Hill's series on Control System Engineering. The book aims to provide the control engineer with those methods of nonlinear systems which are practical in the control field.

The selection of material is such that an extensive background is not required. Only those methods and techniques which are practical from an engineering standpoint have been included, and all mathematics beyond calculus is developed in the book.

Emphasis is placed on nonlinear theory and nonlinear equations. All important points are illustrated by examples, and the book includes a short, concise treatment of linear theory.

ELECTRONIC COMPUTERS, PRINCIPLES AND APPPLICATIONS, edited by T. E. Ivall, 167 pp, $10, Philosophical Library Inc., New York.

A compilation of articles which originally appeared in WIRELESS WORLD, this book is intended for familiarization with computers in general and, as such, stays away from too technical a presentation. Beginning with the evolution of computers and working through both analog and digital types, the book concludes with a chapter on computers of the future. While the material is not too technical, a certain amount of knowledge about electronics is a must.

The editor has chosen material which gives a reasonably broad picture of electronic computing.

when and where

AUGUST

AIEE, IRE, NBS Conference on Electronic Standards and Measurements, National Bureau of Standards Boulder Laboratories, Boulder, Colo., Aug. 13-15.

Industrial Applications of X-Ray Analysis, Seventh Annual Conference, Albany Hotel, Denver, Colo., Aug. 13-15.

Missiles Operations Research Engineering Seminar, Pennsylvania State University, University Park, Pa., Aug. 17-23.

AAS Annual Western Regional Meeting, Stanford University, Dinkelspeil Auditorium, Palo Alto, Calif., Aug. 18-19.

ASME, A.I. Ch.E. Conference, Northwestern University, Evanston, Ill., Aug. 18-21.

Second Symposium on Naval Hydrodynamics, Washington, D.C., Aug. 25-29.

Ninth Annual Congress, International Astronautical Federation, Amsterdam, Holland, Aug. 25-30.

SEPTEMBER

Summer Program, Problems of High-Powered Radar Design, Massachusetts Institute of Technology, Cambridge, Mass. (Security clearance required) Sept. 2-12.

1958 Cryogenic Engineering Conference, Massachusetts Institute of Technology, Cambridge, Mass., Sept. 3-5.

First International Congress of the Aeronautical Sciences, Palace Hotel, Madrid, Spain, Sept. 8-13.

American Rocket Society, Fall Meeting, Hotel Statler, Detroit, Mich., Sept. 15-18.

13th Annual Instrument Automation Conference, Convention Hall, Philadelphia, Pa., Sept. 15-19.

ASQC, 5th Annual San Francisco Bay Area Conference, Stanford University, Palo Alto, Calif., Sept. 19.

Professional Group on Telemetry and Remote Control, 1958 meeting, American Hotel, Bal Harbor, Miami Beach, Fla., Sept. 22-24.

Standards Engineers Society, Seventh Annual Meeting, Franklin Hotel, Philadelphia, Pa., Sept. 22-24.

Air Force Association, Airpower Showcase, Dallas, Texas, Sept. 25-28.

ASME Power Conference, Statler Hotel, Boston, Mass., Sept. 28-Oct. 1.

OCTOBER

IAS Canadian Aeronautical Institute joint meeting, Chateau Laurier, Ottawa, Oct. 7-8.

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keeping track

by Peer Fossen

Scientists here and abroad are drawing up plans to use radio signals to find an answer to the lunar dust problem. The plans involve bouncing a 20-cm wavelength, sharply beamed signal off the moon. Difference in attenuation between transmitted and returned signal will be used to determine existence and magnitude of dust layer. Main problem seems to be the establishment of standards for data reduction. If the theoretical analysis portion of the program can be solved by that time, the first transmissions will take place this fall.

Lincoln Laboratory, Mass., or N.R.L.'s facilities in Washington will handle the transmission. Location for the receiving terminal is Gothenburg, Sweden.

Goodyear Aircraft Co.'s Weapons System Division is currently beaming a lot of effort on a new guidance system for low altitude air-breathing missiles. The new system—named PINPOINT—will feature a mixture of ATRAN and inertial guidance. ATRAN, a map matching system developed by GAC for Martin's *Mace*, TM-76A, relates a film strip, actual or synthetic, to the terrain over which the vehicle is flying. PINPOINT will give more flexibility and accuracy.

Army has submitted a follow-up proposal to take 25 pictures or more of the moon, involving slight modifications of existing *Juno*-II hardware. This would be in addition to the two Army moon probes approved by ARPA.

Best possible photographic result from the earth is a resolution of one kilometer. Current plans for the first *Juno* II's are to take a picture at a distance of from 1,000 to 10,000 miles from the moon. Army would like to get a shot from as close as 300 miles, but doesn't trust its aiming accuracy that much. Land-type camera will take picture through long focal length (narrow angle) lens as it passes target, then develop and start transmission. Sending the picture back to earth may take hours, since limitation on weight and equipment necessitates slow scanning procedure and transmission over a narrow bandwidth.

The proposed follow-up probe would go around the moon, store the pictures, and then transmit them on the return trajectory.

U.S.'s first prototype reconnaissance satellite may also include Land-type camera techniques. Land is currently working on the project with Jet Propulsion Laboratory.

Solar power units will not be included in the *Juno* II project. From a weight-space point of view, solar power is economical only when the power supply is required to be in operation for more than one week.

Released pictures of Sputnik III model indicate that the satellite is equipped with broad-band antennas. (See m/r, July 7, page 10.) Engineers in the telemetry game feel certain these antennas are used for facsimile or video transmission.

For those who are interested, the length of *Subroc* is 14 feet.

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"SHOOTING" RED AND WHITE missile replicas with "haze" box attached to camera, as demonstrated by Raife Tarkington of Kodak Research Laboratories. The box arrangement enables simulation of atmospheric haze on the film.

Twinkling Stars Factor In Missile Photography

The atmospheric effect that makes stars twinkle is a factor in the latest work on missile photography at the Kodak Research Laboratories.

According to Raife G. Tarkington, chief of military photography at the laboratories, the studies have provided new information about the film characteristics needed to photograph far-ranging missiles.

Two factors affecting missile photography—the atmospheric conditions and the diminishing size of the bird as it recedes from the launching point—are reproduced to scale by the Kodak people. Atmospheric haze reduces the apparent contrast of the object, while atmospheric turbulence deteriorates the image formed by the optical system—the effect that makes stars twinkle.

To simulate these effects, a series of white- and red-painted missile replicas were fastened to a blue background. These replicas—which vary in size from ¼ inch to 2 feet—were then photographed under daylight conditions on several types of film, black and white as well as color.

Exposures were taken with each film using a simulated haze of 0, 25, 50, and 100% based upon the reflection of the white-painted missile.

Research has been performed with certain color films in detecting white-painted missiles. This is of great im-

portance in view of the fact that many missiles are rendered white by surface frost formation due to liquid fuel evaporation.

Tarkington said the tests demonstrated, above all, the importance of correct exposure of the film. With incorrect exposure, the smaller missile models are lost completely.

He declared that, in general, the effectiveness, resolving power, and sharpness of missile-tracking films are improved as the film sensitivity decreases. Therefore, the "slowest" film that can be exposed adequately in the system usually is chosen for missile photography.

Machine Computation To Be Discussed

Developments currently taking place in the fields of machine computation and data processing will be major subjects of discussion at the 5th annual Computer Applications Symposium, to be held in Chicago Oct. 29-30 at the Morrison Hotel.

The program for the first day will emphasize business and management applications; the Oct. 30 session will be devoted to engineering and scientific applications.

Topics scheduled for consideration at the business and management session include new concepts in large scale data processing, sharing a data processing facility by several organizations, and inventory and logistics problems.

The future of automatic programming, programming of learning techniques, and literature searching are among the topics to be discussed at the engineering and scientific applications session.

Fourteen speakers will participate in the two-day meeting.

Fred Gruenberger of Rand Corp. will be chairman of the business and management session, and Dr. C. B. Tompkins, professor of mathematics at the U. of California, L. A., will be chairman of the engineering and scientific applications session.

Semiconductors Feature Efficiency, Small Size

New silicon semiconductor devices are offering the computer industry more speed and efficiency and much smaller sizes than ever before, according to Dr. J. R. Madigan, vice president of engineering, Semiconductor Division of Hoffman Electronics.

"What we are achieving with silicon semiconductor devices," Dr. Madigan said, "is first, increasing the switching speed by the use of zener diodes, and

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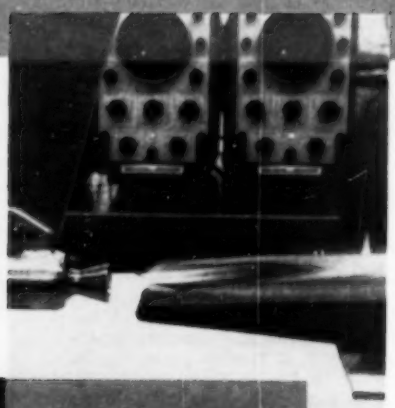

When Temco engineered and developed the aft-fuselage and vertical stabilizer section of Convair's B-58 Hustler . . . the wing section and fuselage panels of Temco's own TT-1 jet trainer . . . the wings of the air-launched "Teal" missile . . . the aircraft industry acknowledged Temco as a leader in development and production of honeycomb sandwich and hi-temperature structures. Missile applications currently programmed are substantial recognition of Temco's stature.

At Temco metal and plastic sandwich structures have been employed in all types of airframe applications, with notable development in the field of stronger, higher heat-resistant metal bondings . . . in improved plastic materials and methods of reinforced plastic honeycomb fabrications.

Other outstanding advances now under development at Temco are a new low-cost process for brazing stainless steel honeycomb structures, employing a revolutionary new concept . . . and experimental progress in the new field of "cermets."

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second, simplifying and speeding up readouts by our developments in photovoltaic silicon cells.

"These zener diodes are replacing slower switching devices formerly used in computers," Dr. Madigan pointed out, "and along with silicon photovoltaic cells, make it possible for computers and electronic control devices to respond more quickly and be smaller and more efficient."

He added that the new devices are more rugged and can be used in end-product computers and control units. "They have a tremendous advantage by the very nature of their construction," he concluded. "Environmental factors do not enter into their operational characteristics."

Solid-State Commutator Features High Accuracy

An electronic commutator for telemetering applications, with high accuracy over a wide range of mixed source impedances, has been developed by the Applied Science Corporation of Princeton Junction, New Jersey (ASCOP).

The new solid state multichannel sampling switch has an input-to-output accuracy of 1% or better for any mixed source impedances up to 25k ohms. This accuracy figure includes linearity and offset factors.

In addition, the new ASCOP electronic commutator develops a back current of less than 1 microampere during the time a channel is "off". This negligible back current completely eliminates the problem of transducer "loading."

Both the accuracy and non-loading features have been engineered as inherent parts of the ring counter-actuated diode gating circuitry, which forms the heart of the new commutator.

The electronic commutator is designed for long-life applications in data handling systems using time-division multiplexing. The commutator will handle 0 to 5V input signals in all I.R.I.G. standard Pulse Amplitude (PAM) and Pulse Duration (PDM) sampling rates. Standard channel configurations are 30 and 45, including synchronization pulses. A choice of combinations is possible.

The electronic commutator retains all the conventional advantages of solid state switching. Power consumption is something less than 3 watts. Design life expectancy is 5,000 hours without maintenance. Operating temperature range is −60°C to +80°C with special packaging available for extreme intermittent temperatures. The commutator's size is approximately 45 cubic inches, and the weight is approximately 32 ounces.

Missile Conference To Be Held in Chicago, Oct. 16-17

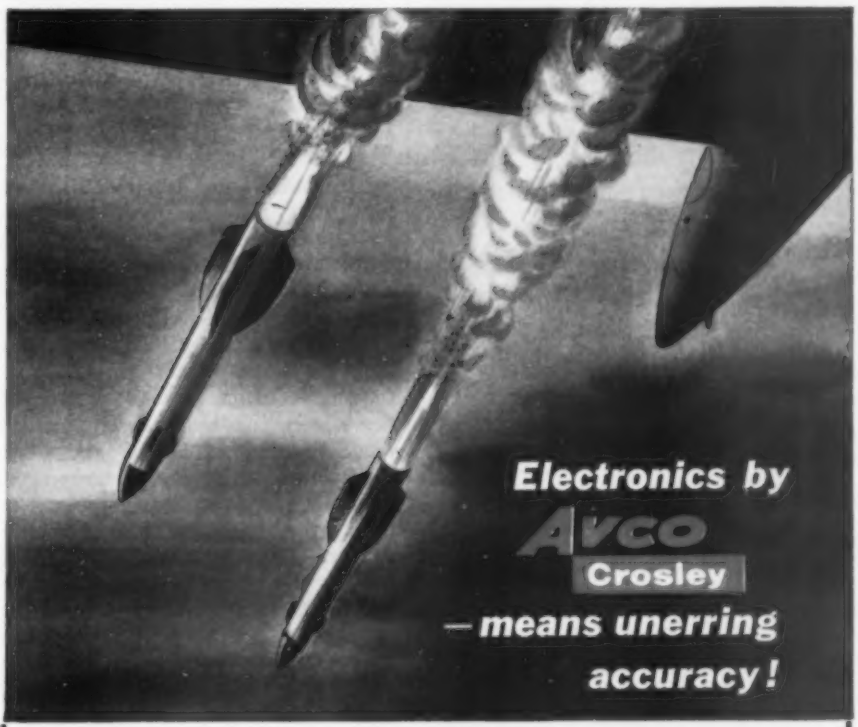
Testing long-range missiles will be described by one of the nation's leading authorities at the 14th annual National Conference on Industrial Hydraulics, to be held at the Hotel Sherman in Chicago on Oct. 16 and 17.

Maj. Gen. Donald N. Yates, commander of the missile test center at Patrick Air Force Base, Fla., will discuss this phase of the nation's missile development program before some 600 hydraulic engineers and industrial representatives at the opening session of the conference.

The subject of his address will be "Problems and Progress in Testing Long Range Missiles."

Another speaker at the opening session will be Kurt Stehling of the Naval Research Laboratory at Washington. Stehling is head of Propulsion Project *Vanguard*.

Ten technical sessions will complete the two-day meeting, which is sponsored by Illinois Institute of Tech-



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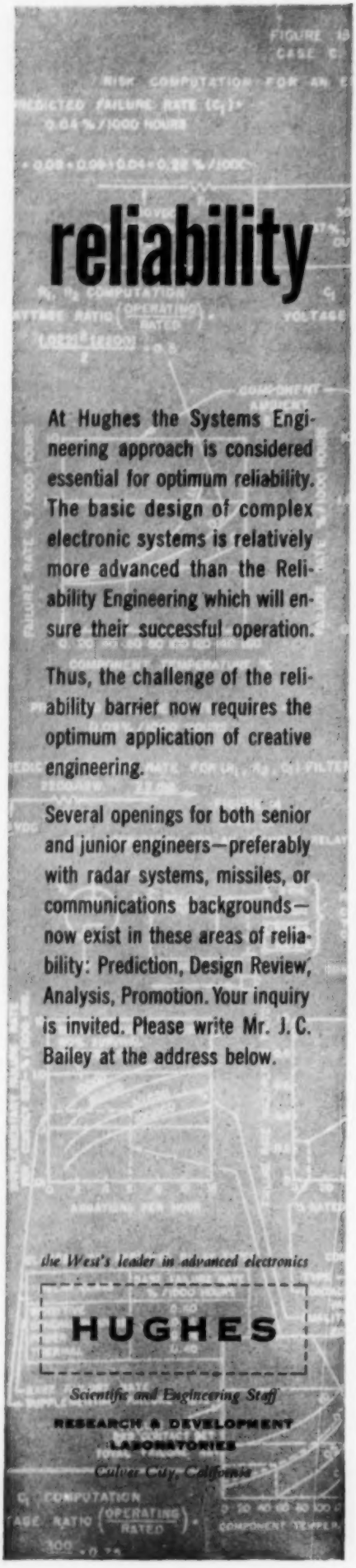
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nology and its affiliate, Armour Research Foundation, in cooperation with several engineering societies and more than 100 industrial organizations.

The program will include 23 papers dealing with latest developments in industrial hydraulics, both fundamental and applied.

Sessions will be devoted to hydraulic applications in the aircraft and automotive industries, hydraulic fluids, presses, components and accessories, pneumatics, pumps, automatic machine tools, mobile equipment, and servomechanisms and systems.

Director of the conference is Ralph J. King of the research division of Caterpillar Tractor Co., Peoria, Ill.

New Magnetic Tape Available for Computers

A radical new "sandwich construction" magnetic tape for computer and instrumentation use that eliminates oxide rub-off, extends equipment life, and outwears conventional instrumentation tapes by 10 times or more has been announced by Minnesota Mining and Manufacturing Co.

Secret of the new tape is a thin, low-friction, plastic layer over the magnetic coating which prevents the oxide from contacting the recording head at any time, thereby eliminating all wear on the oxide itself.

Yet because the plastic layer—purple in color—is only 50 microinches thick, critical head-to-tape contact is sufficiently intimate for all instrumentation recording applications, except those where extremely high frequency response is required.

By eliminating oxide rub-off, the new sandwich tape provides greater reliability and freedom from signal error—especially critical in digital computer applications.

This is because the exposed oxide on conventional instrumentation tapes gradually wears off under repeated use, and the powdered oxide collects on the recording head as well as on the surface of the tape itself. Either condition may cause signal error.

The 3M Company reported that field tests have shown that the sandwich tape will last at least 10 times longer than standard tapes, and in many applications, has a usable life ranging from 30 to 100 times as long, depending on the recording system.

In a computer installation where exposed oxide tapes were usable for only 250 plays, use of the new tape has raised the figure to more than 11,000 plays.

Magnetic properties of the sandwich construction tape differ from conventional instrumentation tapes only in that the 50 micro-inch head-to-tape separation reduces signal level approximately 6 db at 1 mil wavelength. Medium and long wavelength responses are essentially unaffected.

An important feature of the new sandwich tape is freedom from dropouts—minute flaws in the coating causing a momentary loss of signal. The manufacturer stated that the new tape contains not more than a single dropout per roll (based on recording seven tracks on rolls ½" by 2500' long).

Dropout count is measured by inch on a 0.035" track. A reduction to recording 200 non-return pulses per less than 50% normal signal amplitude constitutes a signal error or dropout. Zero errors are measured by saturating the tape unidirectionally. Each spurious signal greater than 10% of normal signal amplitude constitutes a zero error.

Equally important, possibility of dropouts caused by oxide rub-off during subsequent use is almost completely eliminated, the 3M Company pointed out.

Radio Transmission Tests Use Moon As Relay Station

Radio transmission tests using the moon as a passive relay station have been conducted recently by the Signal Communications Department of the U.S. Army Electronic Proving Ground and Collins Radio Co.

According to Collins, these tests probably represent the first time that intelligence, in this case radio-teletype, has been transmitted in the ultra-high frequency region of 1,000 megacycles over the 500,000-mile distance from the earth to the moon and back.

Transmitting station for the tests was located near Fort Huachuca, Arizona, and the receiver was at Encino, New Mexico. The frequency of 810 megacycles per second was utilized in order to increase the effectiveness of the antenna systems, and to take advantage of lower signal losses in the transmission path.

During November, 1952, Collins and the National Bureau of Standards used the moon as a reflector to relay radio-teletype signals from Cedar Rapids to Sterling, Va. In these tests, an ultra-high frequency of 418 megacycles was used.

According to project personnel at Fort Huachuca, this type of communication is limited in range only by the ability to observe the moon simultaneously from both the transmitting and

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receiving points. Some appreciation of the distance involved in this method of communication can be obtained from the fact that a signal, traveling at approximately 186,000 miles per second, requires only 2½ seconds to travel the path from the transmitter to the moon, and back to the receiver.

If an artificial satellite can be utilized for this method of communication, the time of transmission and losses can be drastically reduced.

Tiny Radio Aids Guidance Of Missile to Target

A midget radio station, located in the nose of a guided missile, now helps to map its flight through space.

Developed and designed by IT&T Labs for Sandia Corporation of Albuquerque, N.M., the device can plot a missile's trajectory to within two yards of the target at a distance of 30 miles.

The equipment includes a transmitter on the ground linked to three receivers paralleling the projectile's route. By measuring to 10-billionths of a second, the elapsed time of a signal from ground transmitter to missile and back again to the three ground receivers, it is possible to compute and plot the entire trajectory of the missile from launching to impact.

The airborne transmitter, occupying only 50 cubic inches of space, "had to have perfect frequency phase stability over a wide range of temperature, vibration and shock," according to Albert E. Cookson, director of the ITT Laboratories' missile guidance section.

"As in most missile instrumentation units," he added, "it was desirable that it weigh nothing, occupy no space, draw zero power from the missile, and operate without antennas."

Ramo-Wooldridge Corp. to Transfer R&D Operations

Ramo-Wooldridge Corp. has announced plans to transfer its Advance Electronic Research and Development operations to a 90-acre site to be purchased in the western section of the San Fernando Valley. Construction will begin as soon as the Los Angeles Planning Department grants a conditional-use zone to permit construction.

First units of the new center will provide space for some 2000 scientists, engineers and administrative personnel. The Space Technology Laboratories, R-W's autonomous division, will take over the present R&D center at 5500 W. El Segundo Blvd. when the San Fernando buildings are completed.

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Signal Generators Uses Plug-In R-F Oscillators

Extreme versatility is offered by a new signal generator series comprised of a basic power supply and interchangeable radio-frequency oscillators developed by BJ Electronics, Borg-Warner Corp. Five plug-in oscillator units provide coverage of 20-80 mc, 300-500 mc, 800-1100 mc, 1100-1600 mc and 2700-3000 mc frequency ranges. Two types of modulator units offer the option of high or low power operation in the 500-1000 mc range. Individual design complexity varies according to stipulated frequency range and power level.

In high level operation, the Model 82 Signal Generator Series may be employed as a pole beacon for missile checkout equipment or for general laboratory measurements. In consideration of field use, design and fabrication is rugged and the series substantially immune to adverse environmental effects.

The basic power supply chassis contains 1000-2000 vdc continuously variable high power, and low voltage power supply; a variable-amplitude (1 kc) sine-wave oscillator and square-wave shaper. Provisions are incorporated for front panel indication and control of modulation and power level with an integral blower system to facilitate equipment cooling. The basic 19" x 10 7/16" x 16 x 18" chassis weighs 59 lbs.

Individual plug-in r-f oscillator units contain the remainder of the generator components. According to the manufacturer, the r-f output is substantially constant over the frequency range, with low internal leakage. Front panel control adjustment sets the desired frequency. Accuracy to ±0.5% and frequency stability ±0.1% are stated operating features. Individual weights of the 6 1/16" x 10 7/16" x 17" plug-in units vary from 17 to 20 lbs.

Circle No. 225 on Subscribers Service Card.

Production of Motorola Transistors Announced

Pilot line production of two new Motorola Mesa transistors has been announced. One is an ultra-high frequency amplifier capable of oscillating about 750 megacycles and accepting power gains of 12 D.B. at 200 megacycles. It operates above 100°C.

The device will withstand 50,000 G's of acceleration and will meet or

exceed all existing military specifications for shock, vibration and hermetic sealing.

The other development is a high speed switching transistor designated by No. 2N695. Switching time in saturating circuits is in the order of 10 milli-microseconds, and in non-saturating circuits from 1 to 2 milli-microseconds. Typical saturation voltage is 0.25 volts, and the typical grounded emitter current gain is 30.

Circle No. 226 on Subscriber Service Card.

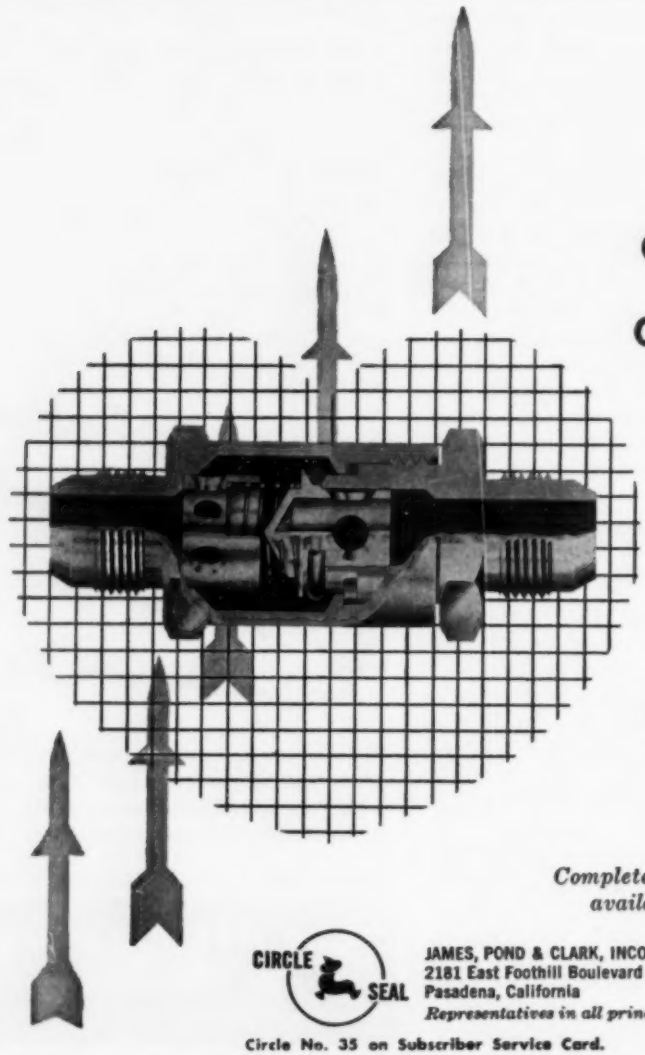
Miniature 16-Watt Servo Amplifier Available

Kearfott Co. Inc. has introduced an addition to its line of servo amplifiers. Designed to deliver control phase power to 400 cycle servo components

requiring up to 16 watts of input power, this unit consists of an output push-pull stage, a driver push-pull stage, a phase splitting stage, and a voltage amplifier stage.

A plug-in type component, this amplifier is completely potted in a compound having such high shock absorbent properties that four times the "g" value of maximum impact specified by the appropriate military environmental testing specification is easily sustained.

Voltage gain of the amplifier is



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Analog computers, advanced chemical and physics test equipment spell out the dimensions of the Edison Research Laboratory—one of the finest facilities of its type anywhere.

Edison's new servo program computer for an advanced—and classified—missile system sets new standards in lightness and compactness. Built entirely with Edison-manufactured components, this new unit weighs only 14 ounces, occupies only 14 cubic inches.

Within this size and weight Edison has created a complete servo computer package—containing transistorized and magnetic amplifier circuitry, servo-motor, precision gear train, two resolvers in a complete servo loop. The whole unit is hermetically sealed and highly resistant to corrosion and vibration.

Offering an optimum in response and sensitivity, this system shows the way to a wide variety of applications in missile control duties. It exemplifies the Edison capability in missile system design and manufacturing.

Because the Edison organization includes development and production facilities for servos, servo systems, magnetic amplifiers, computers, transducers, precision gear trains and miniature relays, Edison can become the *single source* for major electronic system assignments . . . can speed up prototype development faster than any other company. The Edison team concept in engineering, and unexcelled research laboratories for its scientists—are the other basic ingredients for success in advanced electronics projects.

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adjustable between 100 and 2,000 for a 40 volt load, and between 300 and 6,000 for a 115 volt load. The gain desired is obtained by employment of an external resistor, and when driving a 115 volt load, an impedance-matching output transformer is used in conjunction with the amplifier.

Measuring 2½"x2 3/8"x2¼", the A3104 transistorized servo amplifier is a versatile component, particularly in missile applications. The unit may be mounted in any position by means of captive screws which are available in various lengths to suit the user's application or particular need.

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Tri-Axial Accelerometers Aid in Vibration Test

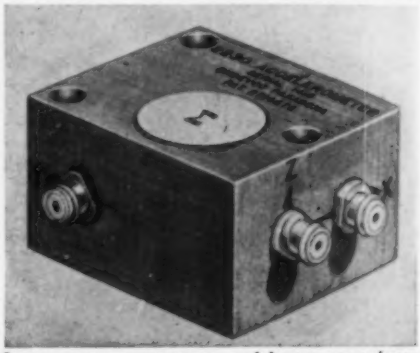
A new tri-axial accelerometer aids in conforming with the new vibration specifications for simultaneous measurement in three axes.

Three sensing elements are mounted in mutually perpendicular planes within a small compact block measuring 0.75"x1.25"x1.31".

Endevco Corp's. model 2243 (below) is designed to operate over a temperature range from −100°F to

+500°F, with maximum change of 10% in sensitivity, while model 2230 (below) operates accurately over the normal temperature range of 63°F to +200°F.

Both units have natural frequencies of 25 KC or more to assure wide flat



frequency response without spurious resonance. Sensitivities are 5 to 9 millivolts per g. A three point mounting is used to guarantee secure mating to test surface and proper orientation. Both accelerometer cases are electrically isolated from stray ground loops in the test structure.

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Copper Shield and Jacket In Single Operation Possible

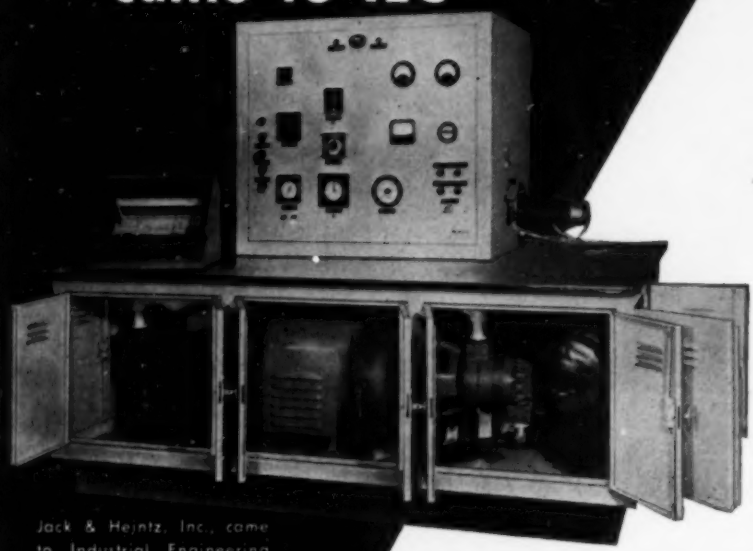
A copper shielding method which supplies a copper shield and a jacket

for wires and cables in a single operation is a new development of the Zippertubing Company.

Copper shielded zipper tubing is closed by a plastic or metal zipper track and, thus, easily may be zipped around wires and cables, giving 100% coverage. Great labor and equipment savings

Need test stands?

JACK & HEINTZ, INC. came to IEC



Jack & Heintz, Inc., came to Industrial Engineering Corporation for the design and construction of this electrical actuator test stand for testing Boeing B-52 component parts.

IF your problem is functional test equipment or control panels, Industrial Engineering Corporation can supply the answer. Whether your needs call for the use of hydraulic, pneumatic, electric or electronic principles—singly or in any combination — IEC has the imagination, the ability, the facilities to handle the job *right*, from original design to actual installation.

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Circle No. 36 on Subscriber Service Card.

are possible, as one man can close approximately 20 feet of zipper tubing per minute, while an expensive braider will shield a maximum of 1,500 feet per day.

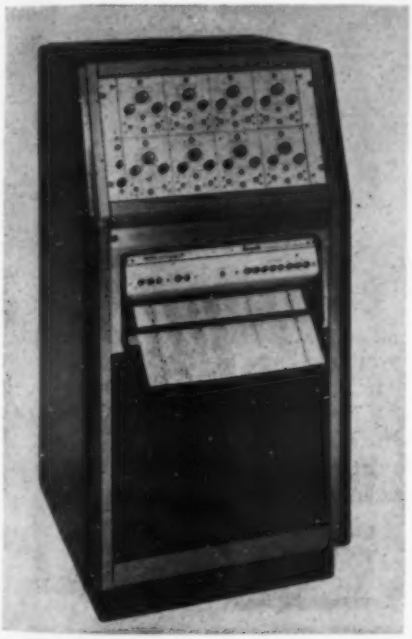
Shielded zipper tubing is available in inside diameters from 3/8" up in increments of 1/8". Standard color is gray, and standard put-ups are 25', 50', 100' and 300'.

Circle No. 229 on Subscriber Service Card.

8-Channel Recorder Now Being Marketed

A new, 8-channel ultralinear recording system, Model RD 1684 00, with rectilinear readout and thermal writing, is being manufactured and marketed by Brush Instruments, division of Clevite Corp.

The new medium gain dc system features a choice of two individual plug-in amplifiers. One amplifier has high sensitivity of 10 millivolts per chart line (mm) with a stability better than ½ chart line per hour. The other



amplifier features stability, better than 1/10 chart line per hour, and a sensitivity of 50 millivolts per chart line (mm).

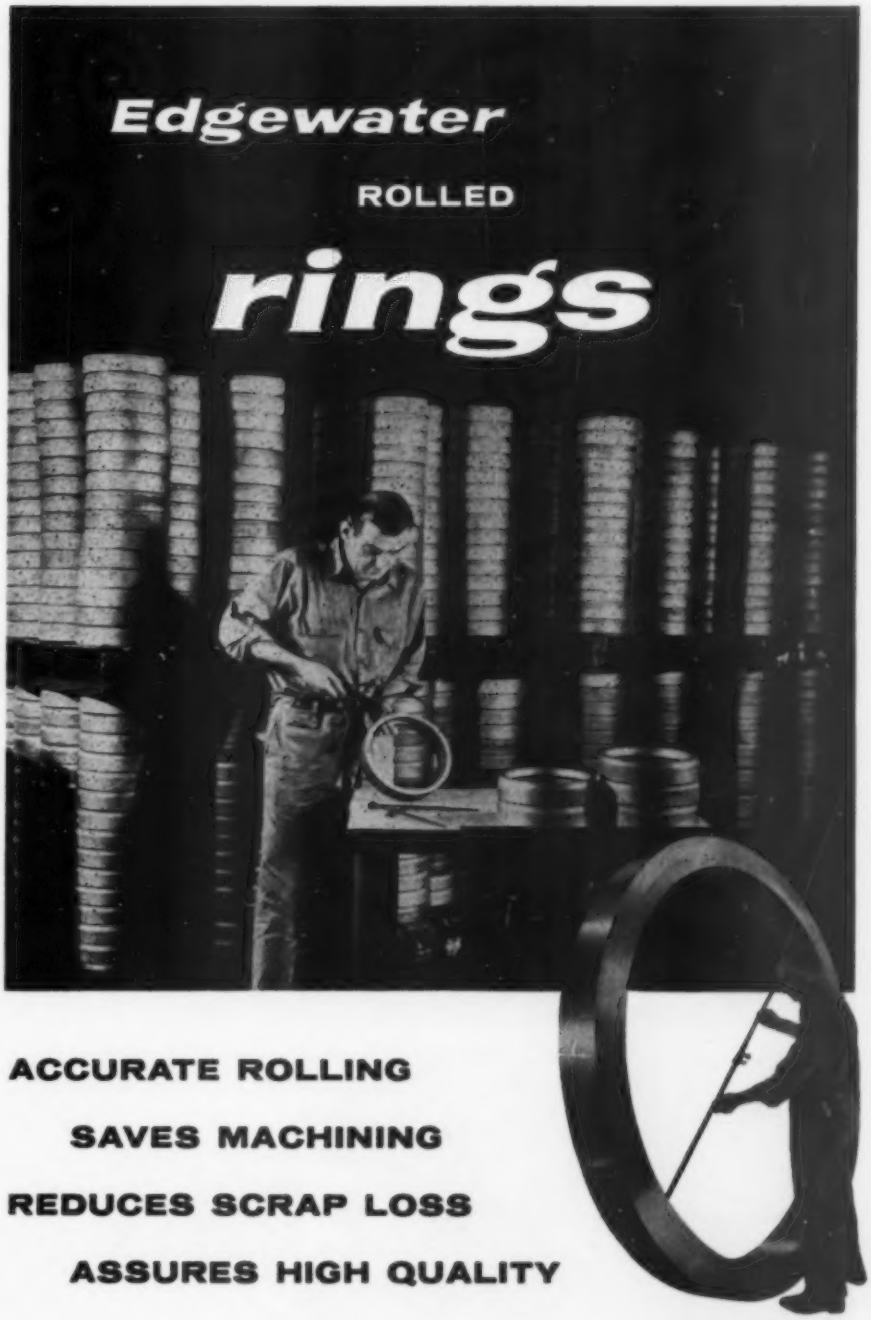
Thermal writing feature of the new system provides immediate traces, uniform both in density and width, producing easy-to-read charts.

Circle No. 230 on Subscriber Service Card.

Recorder Designed For Missile Test Vehicles

A recoverable 25-channel on-board digital tape recorder designed for use in missile test vehicles has been developed by Aerophysics Development Corp., a subsidiary of Curtiss-Wright Corp.

As a complete on-board recording



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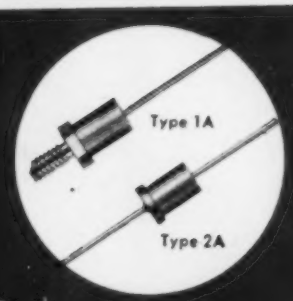

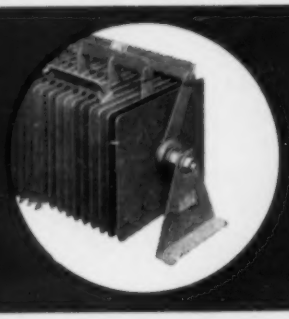

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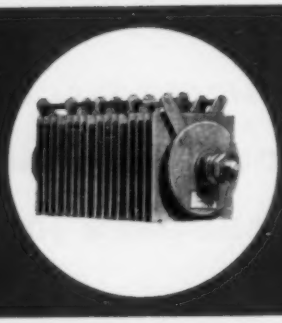
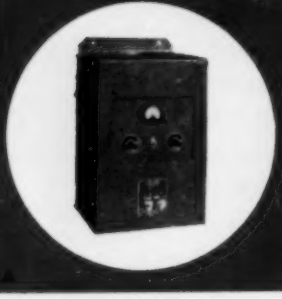
SELENIUM HIGH TEMPERATURE POWER RECTIFIERS (to 150°C)

Ask for Bulletin 6.401





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system, the recorder ties up no ground facilities. The unit may be flown both as a primary recording system in smaller test vehicles, or as a back-up system for larger missiles with telemetry systems.

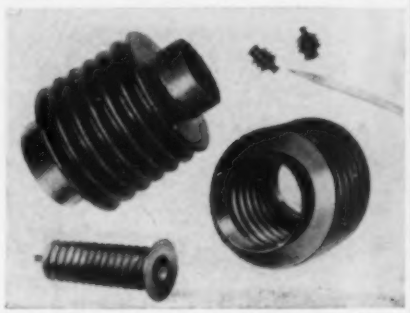
The recorder can be operated to determine time-of-event, magnitude, digital relationship and pulse rate frequencies in excess of 100 cps. Data resolution is in excess of 5 milliseconds, and extreme accuracy may be attained by use of binary encoding cards if a limited number of events are to be monitored.

Weight of the recorder, including cylindrical armored protective case, is less than 4½ pounds. Outside diameter 4½ inches, height 4-1/8 inches.

Circle No. 231 on Subscriber Service Card.

Intricate Bellows Typical Of Varied Parts Available

These bellows are typical of the many and varied types of rubber and



synthetic parts by the Mechanical Rubber Products Co.

MRPC offers help in designing, rubber compounding, molding and fabricating every conceivable type of mechanical goods in rubber and synthetics.

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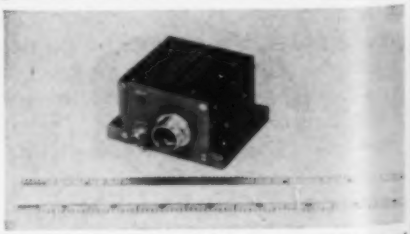
Transistorized Amplifiers Available in Small Size

Development of transistorized amplifiers, one-third the size of equivalent



tube type units, has been announced by Glennite Instrumentation Div., Gulton Industries, Inc.

Needing no filament power and only 20% of the plate power required by tube type amplifiers, the amplifiers are designed to amplify signals from high impedance transducers to feed

directly into standard electronic meters, recorders or telemetry equipment.

Operating at a temperature range of –65°F to +240°F., the new instruments are low microphonic voltage amplifiers, specially designed for use in missiles.

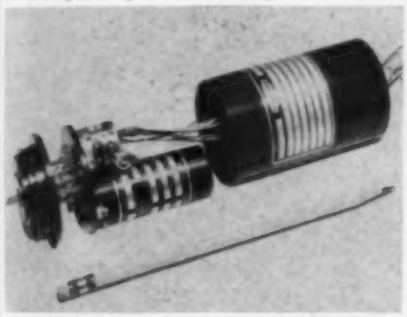
Housed in anodized aluminum cases, the units operate with a recommended minimum load of 10,000 ohms, maintain a voltage gain that is continuously variable between 10 and 100, and perform with negligible vibration noise characteristics.

Circle No. 233 on Subscriber Service Card.

Miniature Turret Package Assembly Developed

A means of assembling precision rotating servo components in miniature turret packages is now available from Mechatrol, a division of Servomechanisms, Inc.

The photograph shows a typical turret package containing a size 11



motor-tachometer, a gearhead, and a potentiometer, all encased in a package less than 5" long, with a nominal OD of 2¼". Other servo components, such as transistorized amplifiers, and synchros, can be added as needed. Clutch and limit stops may be added.

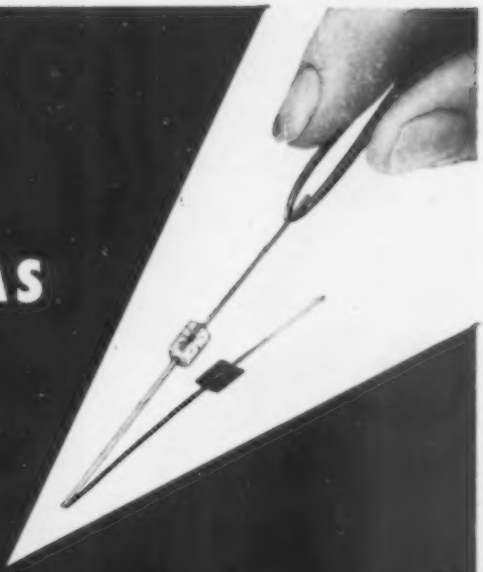
Circle No. 234 on Subscriber Service Card.

Miniature Tantalum Capacitor Line Announced

P. R. Malloy & Co., Inc., has announced a brand new line of hermetically sealed tantalum capacitors—first

to offer 150°C operation in so small a size. Known as the M_2 line, the units

SIZE REDUCED AS MUCH AS 61%



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SPECIFICATIONS AND ORDERING REFERENCES

	Catalog Number	Capacity in Mfd.	Working Voltage	Range Number
85°C	STA-157	3.5	10	11
	STA-143	2.2	15	12
	STA-169	1.5	20	21
	STA-171	1.2	30	22
	STA-173	1.0	35	23
85°C	STA-157	2	10	11
	STA-143	1	15	12
	STA-167	3	20	21
	STA-171	1.5	30	22
	STA-173	1	35	23
85°C	STA-157	12	10	11
	STA-143	11	15	12
	STA-167	8	20	21
	STA-171	5	30	22
	STA-173	3	35	23
85°C	STA-157	70	10	11
	STA-143	45	15	12
	STA-167	35	20	21
	STA-171	25	30	22
	STA-173	20	35	23

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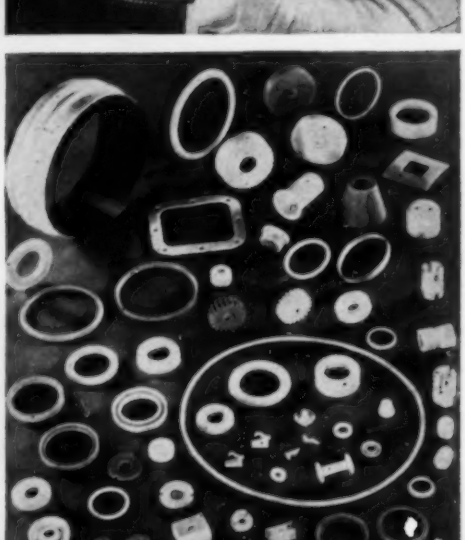

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These are the reasons why you should come to R/M for *all* your "Teflon" needs. R/M fabricates standard products such as covered flexible "Teflon" hose, thin wall tubing, sheets, tape, tubes and rods. Also parts and components fabricated to your specifications—and sheets, rods and tubes in certified and stress-relieved grades (X-ray films for sheets and rods are available), and centerless ground rods held to very close tolerances. Write for free literature and more information.

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. . . new products

measure only 0.50 inches in length by 0.287 inches body diameter and 0.484 flange diameter.

These capacitors will withstand up to 150°C temperature and 2,000 cycle vibrations in accordance with MIL-C-3965B, and severe environmental conditions.

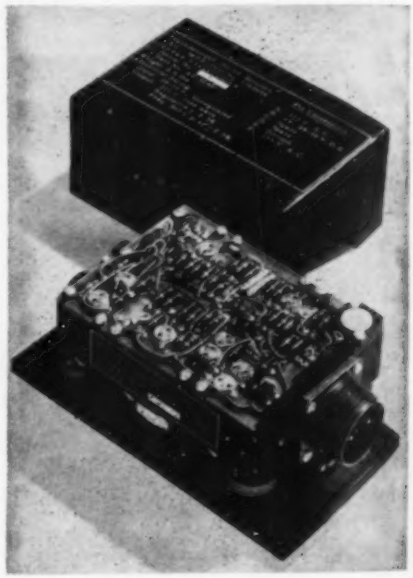
They are available in a wide range of capacities from 11 mfd. 90 volts to 140 mfd. 6 volts at 85°C; and from 11 mfd. 75 volts to 140 mfd. 4 volts at 150°C.

Circle No. 235 on Subscriber Service Card.

Lightweight Static Inverter Provides Sine Wave Power

Jordan Electronics announces all-transistorized sine wave power inverters with three power outputs; 100 V.A., and 150 V.A., and 500 V.A.

The 150 V.A., 800 cps unit shown provides 115 V ± 2.5% output,



(0-100% load) with 26-30 V dc input at mounting base temperatures from −55°C to +85°C and a minimum efficiency of 60%. Input surges to 40 volts can be handled. The frequency tolerance is ± 2.5% and the distortion is less than 5%. A self-resetting "electronic circuit breaker" protects the unit from overloads, including short circuits.

Weight is 3.6 pounds (.024 lb. per watt) and size is 3½" wide x 5 3/8" long x 3" high, excluding connector and mounting flanges, according to the company.

Other models now in production supply 100 V.A. at 115 V 400 cps and 500 V.A. 3 phase, and can be modified to various power outputs and frequencies of 800 cps, 100 cps and 1600 cps.

Circle No. 236 on Subscriber Service Card.

letters

Liquid Still Used

To the Editor:

There seems to be a tendency these days among many people to write off liquid-propellant rockets and missiles as obsolescent items.

With solid propellants currently enjoying much publicity and much fanfare, the liquid engine seems to be forgotten.

We at Aerojet are working on both solid and liquid rocket engines. We are currently developing a large liquid rocket engine for the Air Force *Titan* ICBM.

There are about 4,000 people in our liquid rocket plant who don't buy this idea that liquid engines are on the way out.

Joseph J. Kipper
Aerojet-General Corp.
Sacramento, Calif.

There is room in the space age for both liquid and solid systems. Neither are optimim—Ed.

Older Men Welcome

To the Editor:

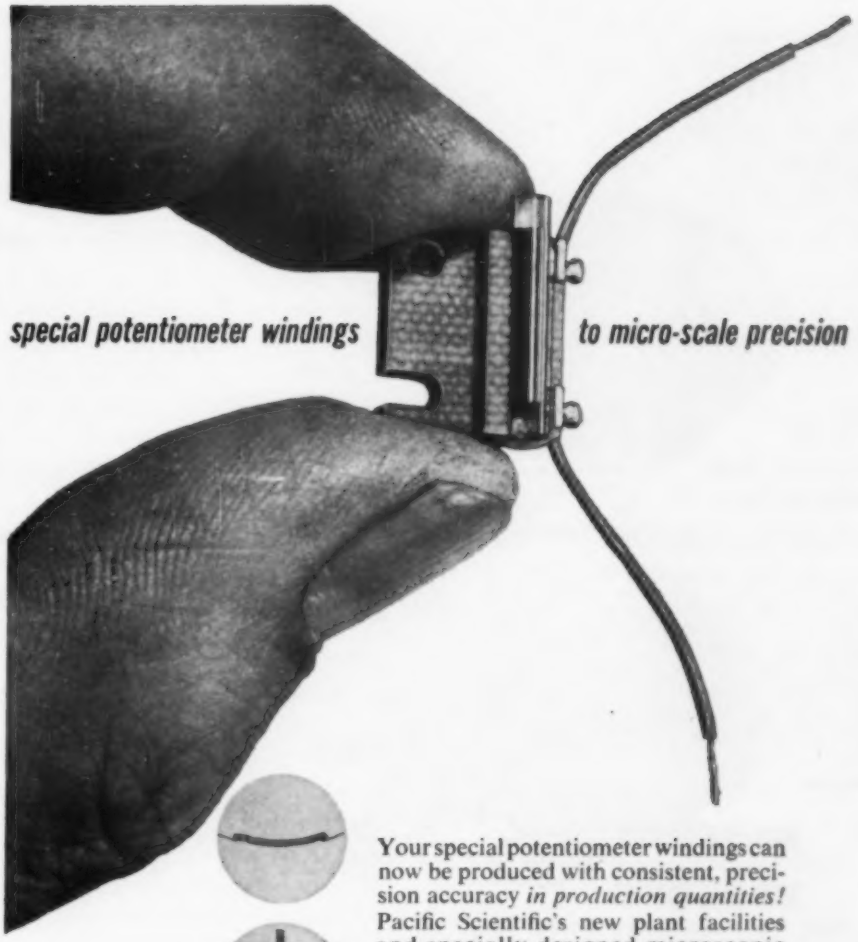
We note with interest the "Letter to the Editor" that appeared in the July 14 issue of m/r, sent in by Mr. James E. Hill of Utica, N. Y., regarding the fact that older engineers are not being utilized by industry.

We wish to advise that Stavid Engineering, Inc., Plainfield, N.J., does and has interviewed and utilized an appreciable number of engineers over the age of forty-five and, as a matter of fact, has on its present staff a good number of men over the age of sixty-five, who have been forced into retirement.

We do not feel that the magical age of forty-five delegates a man to the "industrial scrap heap" and greatly appreciate receiving resumes from the mature engineer.

Eugene B. Kelly
Personnel Director
Stavid Engineering, Inc.

Of interest to our readers is the fact that Stavid not only welcomes job-hunters past 45, but also those past normal retirement age of 65. Of its 250-man engineering force, twenty-five are over 50. All but one were over 45 when they were hired, and ten were over 60 years of age. Stavid acknowledges there is practically no turnover problem. Moreover, the experience of older engineers rubs off on the younger personnel—Ed.



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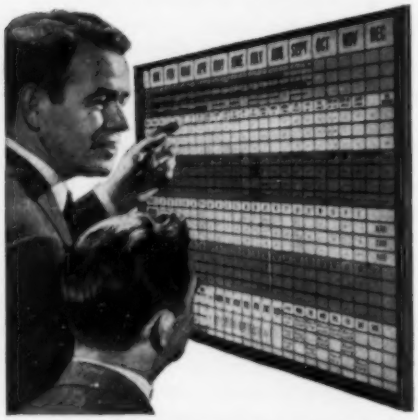

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space age

by Norman L. Baker

Broad overlap of jurisdiction, and the resultant indecision on roles and missions of civilian and military space agencies, is rapidly producing what may be a major impediment to an accelerated national space exploration program. Scientists of both groups constantly refer to the "gray zone," "gray zone in the middle," "broad twilight zone of dual usefulness" and finally, the "gray zone of overlap."

The military scientists, currently the most active space pioneers, have their interest in space necessarily limited by the requirement of defining a project's military usefulness. For instance, many are contesting the decision to place the reconnaissance satellite under military jurisdiction when it will also be invaluable for long-range weather forecasting and world-wide communications.

Less than 24 hours after signing into law legislation establishing NASA, the new civilian space agency, President Eisenhower asked Congress for an additional $125 million for the new agency. In addition, DOD will transfer to the agency $117 million appropriated earlier for non-military space programs.

The million-pound thrust engine, held back for many years because it had no foreseeable future as a military weapon powerplant, is slowly getting underway as a result of plans for manned satellites and rocket-boosted glide bombers. Rocketdyne, in the past few days, has received an Air Force contract to build major components for a single-chambered million-pound unit. Incidentally, the company's foresight is credited with reducing the lead time for this engine by several years. Rocketdyne has continued research on large liquid propellant units, beyond military needs, almost entirely on its own time and expense. This huge engine, with a thrust chamber of 17 feet, has long been past the design stage with no formidable obstacles expected in development.

Liquid engines of 300,000-lb. thrust will be the next Rocketdyne contribution to space age power systems. Several tests of over 10 seconds duration have been made at Santa Susana test facilities. First tests using stock *Atlas-Thor* 150 k (company engineers' own abbreviation for 1,000-lb. thrust) engine developed 290 k with a pressure feed system. Engine was operated with a chamber pressure of approximately 1,000 psi (average pressure—600 psi). Final design for 300 k engine will be turbine fed, operate with an average chamber pressure, and have a combustion chamber 18 inches longer than 150 k unit.

The Army map service, evaluating tracking data from the *Explorer* satellites, expect to reduce mapping errors in the Pacific from ¾ miles to 300 feet. Ultimately—a reduction to 30 feet throughout the world.

Long range missile sites must be built underground in 'hard' positions. This, many military officials agree, is the only way to insure retaliatory capability.

Emergency flap drive on Boeing 707 Stratoliner is provided by Airborne Model R1624-1 special-design rotary actuators. Units are permanently coupled to flap linkage, provide electro mechanical drive in event of hydraulic failure. Output shafts are driven whenever hydraulic system operates, but because of special inertial clutch, rotors do not turn unless energized.

AIRBORNE LARGE SPECIAL ACTUATOR SOLVES EMERGENCY FLAP DRIVE REQUIREMENTS ON BOEING 707

Specifications: Motor: 200/115 v a-c, 400 cycles, 3-phase, reversible. Speed at rated torque (450 in-lb): 85 rpm ± 10 rpm. Duty cycle 3 min. on, 27 min. off. Operating range: 102-124 v (line to neutral); 380-420 cps; −65 to +160°F; 0-50,000 ft. Weight 12 lbs.

In addition to offering an extensive line of modular-type electromechanical actuators, Airborne can also meet your requirements for large special designs—linear or rotary. Typical of these special Airborne actuators is Model R1624-1, used on Boeing's new 707 Stratoliner to operate the flaps in the event hydraulic power is lost. At the right are some of the more difficult engineering problems that were presented by this specialized application, along with Airborne's solutions to them.

PROBLEM	SOLUTION
Rotor to be disconnected from output gear stages except when motor is energized in either direction.	Inertial clutch—consisting of small weights in a cage—incorporated between motor and gear train. Makes positive contact with intermediate drive gear only when rotor shaft turns.
Starting torque to be 800 in-lb minimum, with pullout torque of 900 in-lb (±100 in-lb) at 50% motor slip (±10%) under all voltage, frequency and environmental conditions.	Special lightweight motor developed by Airborne to meet these exacting requirements. Rated .9 hp at 10,300 rpm, drawing 2.5 amp maximum.
In event of a jam in actuator transmission or rotor, unit to be fail-safe by permitting rotation of output shaft by torque of 1000-1300 in-lb. Once started, rotation to be maintained by torque not exceeding 100 in-lb.	Special ball-detent, torque-limiting clutch incorporated on output shaft.

Contact us for recommendations on your special actuator requirements . . . or for information on Airborne's standard line of modular design actuators.

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Vought Vocabulary

re·lent′less: *a missile that pierces hostile sky to pinpoint its nuclear strike*

When a target's latitude and longitude are marked on this missile's brain, an appointment has been made.

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In minutes, *Regulus II* can pierce over 1,000 miles of hostile sky to score a nuclear bull's-eye.

The first of the Navy's nuclear-driven subs, designed to roam the seas as unseen *Regulus II* bases, is now in construction. The missile itself has made over 25 successful flights. Under Navy leash in key locations, it will be a relentless watchdog for peace.

Scientists and engineers: pioneer with Vought in new missile, manned aircraft, and electronics programs. For details on select openings write to: C. A. Besio, Supervisor, Engineering Personnel, Dept. P-8.

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Oceanographers. Astrodynamicists.

Their perspectives are worlds apart. But a broad search for advanced weapons is bringing them and other diverse specialists together at Chance Vought.

Vought's rapid advance into new weapons areas is the natural outcome of 41 years of successful aircraft design and manufacture. A pioneer in the missile field, Vought's *Regulus I* has been operational since 1955. The submarine-based *Regulus II* is now in production. The record-smashing *F8U-1 Crusader* was the predecessor of the all-weather automated fighter, *Crusader III*, which made its first flight this spring. Vought is currently working on the Dyna Soar project as a member of the Boeing space glider development team.

Today at Chance Vought, development work fans out into virtually every known dimension of weapon systems.

ANTISUBMARINE WARFARE (ASW)

Vought is engaged in ASW studies under the Office of Naval Research and the Bureau of Aeronautics. Extensive research and development is being done in the vital detection and classification phases. Goal is to bring detection abreast of destruction capabilities.

Vought applies to this work a preeminent background in sea-going missiles: 10 years' experience in installing, testing, observing Regulus *Fleet missiles; an intimate knowledge of submarines.*

ASTRONAUTICS

Vought is actively studying space research vehicles. Projections of this work point to man in space. Vought's Astronautics strength is experiencing rapid growth: up to a 50-fold increase in less than two years in some groups. Through this astronautics nucleus, Vought swells the space capability of its entire engineering organization.

Vought's major contribution to U. S. man-in-space technology: a rich source of cockpit and capsule knowledge.

WEAPON SYSTEMS PLANNING, ANALYSIS

This body of Vought specialists is determining future weapons requirements; defining new areas for closer evaluation. Under way are studies of nuclear-powered missiles and other original applications for today's explosion of propulsion possibilities.

In this area, breakthroughs already have been scored in antenna design, in high-strength structural steel casting for spatial speeds, and in controls and hydraulics.

Launch Systems Engineer
(Preliminary Design)

A seasoned design engineer with field experience. To concentrate on improving orderliness, reducing volume of support equipment. Should be able to design the field system, and prescribe component equipment.

ASW Detection Specialist

Physicist or Electronics Engineer with Sonar or electromagnetic detection experience. Familiarity with submarine tactics, equipment highly desirable. To devise new methods for submarine detection, conduct necessary preliminary analyses, and prepare information leading to hardware design for laboratory testing.

Astrodynamics Specialist

Physicist, Engineer, Astronomer with knowledge of orbit calculations, and experience in digital computers and accurate integration techniques for computing space trajectories.

Preliminary Design Engineer

Capable of turning approximate dimension, thrust, payload and mission information into usable configurations. Requires the mechanical ability to provide for separation of stages; a good feel for missile weight and balance; ability to devise reliable, uncomplicated control systems.

Qualified scientists and engineers who would like to evaluate more thoroughly the opportunities afforded today at Chance Vought are invited to write in confidence to Mr. A. L. Jarrett, Manager, Advanced Weapons Engineering, Dept. P-8.

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missile business

by Seabrook Hull

"Look at the missile next to you. A year from now it won't be there!" The missile rationalization we've been warning you about for the past several months is about to begin. As one high Pentagon official puts it: "It will be an agonizing reappraisal." Insofar as humanly possible, it will:

—ignore the vested interests and desires of any specific military service or industrial grouping.

—relate actual operational capability, rather than claims and dreams, to the missions essential to the execution of basic Western strategy, namely an in-being readiness for massive retaliation.

—evaluate the cost in dollars in each instance against competitive systems and in relation to over-all cost and total funds and resources available.

This reappraisal will be conducted by the Office of the Secretary of Defense, rather than by the Joint Chiefs of Staff or the military services, either individually or collectively. Those responsible for making the basic decisions are well aware that some of the claims of Army, Navy or Air Force for their pet birds may be considerably colored.

There may be some surprises. For example, both *Thor* and *Jupiter* may be tossed out of the running as durable weapons systems. Actually, there are two alternative approaches to this one. First, a decision can be made between *Thor* and *Jupiter* as *the* IRBM, but this cannot be done until such time as the full *Thor* has successfully completed three flights and a fair comparison can be drawn. Second, however, both can be relegated to the primary role of space-flight propulsion units, and *Polaris* be given the main land-based IRBM job. This means a few *Thors* or *Jupiters* would be built for the interim, but that big production would go to *Polaris*.

Defense Department is vitally concerned because none of the big liquid propelled missiles assure the U.S. of the massive retaliation capability so necessary to the military stand-off with Russia. Yet DOD officials argue, there is nothing inherently in the *Polaris* system that precludes its use on land, as well as underwater. *Polaris*, they pointed out, could not only be fired "instantaneously" (it uses solid propellants and requires no last-minute fueling), but here is an instance where two important roles could be filled at the cost of one.

A similar choice will be made within six months between *Atlas* and *Titan*. Defense Secretary McElroy is convinced that we neither need nor can afford both. Whichever one is dropped, however, as a weapon will have some of its better features incorporated in the other. If we had to guess, we'd say *Titan* goes and *Atlas* stays—though some *Titans* would be completed for test purposes and as space flight vehicles.

Minuteman cannot be picked as a substitute for either *Atlas* or *Titan*. It is scheduled too far into the future. Reason for this is *Minuteman's* combined limitation of maximum miss distance vs. payload. In order to guarantee the same minimum impact on target as *Polaris, Jupiter* or *Thor*, taking into account best guidance currently available, the proposed solid propellant ICBM would have to have approximate a 50 megaton warhead compared to three megatons in *Atlas*. As presently conceived, *Minuteman's* warhead is on the order of one-half megaton. Either more accurate guidance for a smaller maximum miss distance or better propulsion for a bigger warhead, or both, will have to be achieved before *Minuteman* becomes a practical consideration. Despite Air Force enthusiasm for the concept, the Secretary of Defense's office is insisting that work concentrate in these two areas before spending a lot of hard-to-get money on other aspects of the weapons system.

contract awards

LAST MINUTE AWARDS

H. B. Zachry Co. of San Antonio, Texas gave Parabam, Inc. $280,000 for design and fabrication of twenty-two astrodome type tracking camera shelters.

NAVY

By Aviation Supply Office:

Ronan & Kunzl, Inc. received $258,720 for trailer, liquid oxygen.

By Purchasing Office:

Bendix Computer Div., Bendix Aviation Corp., received $49,500 for computer, digital.

Hallamore Electronics Co. received $27,804 for telemetering equipment.

By Bureau of Ships:

Western Electric Corp. received $270,000 for the production of magnetron tubes capable of generating ten-million-watt radar pulses.

By Bureau of Ordnance:

Western Electric Co. received $3.7 million for the production of weapon direction equipment.

By Bureau of Ships:

United States Rubber Co. received $29,828 for conducting a study directed toward development of room temperature vulcanizing elastomers or absorption of neutrons.

By District Public Works Office, Eleventh Naval District:

W & M Investment Co. received $283,693 for construction of guided missile support facilities.

AIR FORCE

By Memphis Air Force Depot:

Ronan & Kunzl, Inc. received $74,900 for hose assembly-transfer liquid oxygen.

Welding and Steel Fabrication Co., Inc. received $78,750 for hose-assembly-transfer liquid oxygen.

By HQ, Middletown Air Materiel Area:

Gas Industries Inc. received $1,682,301 for liquid oxygen and liquid nitrogen.

By HQ, AFMTC, ARDC:

Pan American World Airways, Inc. received $67,758,536 for increase in funds.

By Cmdr. HQ, AMC, Wright-Patterson AFB:

Keco Industries, Inc. received $78,650 for dehumidifiers, film drier, engineering data and technical data and ground support equipment.

Ladish Co. received $85,803 for development procedures for the production of sound high-strength steel forgings for aircraft parts by the superimposition of vibratory forces, in addition to normal forging forces.

By HQ, AFFTC, ARDC:

General Electric Co., Missile & Ordnance Systems Dept., received $96,557 for investigation and evaluation of methods of lubrication for reducing of frictional wear.

Research & Advanced Development Div., Avco Mfg. Corp., received $58,411 for fluorine compatibility test equipment.

Haskel Engineering & Supply Co. received $76,505 for helim booster compressor.

Cook Electric Co., Cook Research Laboratories Div., received $64,612 for engineering study.

G. W. Galloway Co. received $91,857 for nitrogen & helium distribution system.

Motorola, Inc. received $106,767 for development of air operational prototype remote data acquisition and transmission system.

Cook Electric Co. received $79,352 for development of mono-rail water brake vehicle.

Motorola, Inc. received $61,425 for microwave data transmission system.

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NEW PRODUCT BRIEFS

TRANSISTORIZED OSCILLATOR. Transistorized sine wave oscillator replaces tuning fork designs for aircraft, missile and other electronic applications. The compact unit, about 2" x 2" x 3" in size, has an adjustable frequency set range of 20 cycles per second to 200 kcps. It is available in plug-in or header type construction. General Controls Co.

Circle No 237 on Subscriber Service Card.

TRANSDUCER LINE. For applications in the missile and process control fields. The units can be manufactured to a wide range of specification and are believed to offer significant advantages in applications requiring conversion of small linear motions into large angular motions. Research Consulting Associates.

Circle No. 238 on Subscriber Service Card.

REDUCTION MECHANISM. A series of motors utilizing a gearbox, clutch and re-set mechanism capable of a 7 million to 1 reduction. This provides a shaft rotation as slow as one revolution in 32 hours. The clutch will drive a load of 45 oz.-in., and the return spring will exert up to 65 oz.-in. of torque. Dalmotor Division, Yuba Consolidated Industries, Inc.

Circle No. 239 on Subscriber Service Card.

ENCODERS. A line of 8-4-2-1 Binary-coded decimal shaft encoders has been announced. Five models cover a range of 2 to 6 decades, providing 100 counts per turn, and employing a standard size 23 BuOrd synchro mount. The units use self-selecting brush V-scan logic, eliminating external anti-ambiguity electronics. Norden Division, United Aircraft Corp.

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LIGHT SOURCE. A new light source, a Zirconium Art, has been adapted for monochromators, greatly increasing precision and giving true colors. This comparatively new light source has the highest intensity ever developed for high power or oil emersion microscopy, and related fields. Cambridge Thermionic Corp.

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INDICATOR TUBE. An addition to its line of Nixie Indicator Tubes called the Jumbo Nixie—type BD-307. This three inch diameter, all electronic in-line indicator, is designed to meet the needs of visual presentation at viewing distances of over 150 feet. Low power and rugged construction are additional features. Burroughs Corp., Electronic Tube Division.

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SPECTROMETER. A high precision Multichannel Scintillation Spectrometer is now in production. The system has 120 channels, taken 20 at a time for rapid, accurate analyses of pulse height distributions. Some applications are high speed scintillation spectrometry, pulse height analysis of low intensity sources, spectral analyses with a minimum of decay corrections for short-lived isotopes. Baird-Atomic, Inc.

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POWER RELAY. A miniature version of a power relay in a clear polystyrene enclosure, with octal plug-in header. This relay is availeble up to 3 PDT, with standard contacts rated at 10 amps, and can be wired for double make or break operations, AC or DC coil. Kurman Electric Co., Div. of Norbute Corp.

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TAPE READER. Dykor Model C301, a photoelectric perforated tape reader, is available to handle any one of the standard punched tape widths. Reading speeds range from 100 characters per second to 750 characters per second. The fast start-stop feature permits intermittent reading of tapes at slower rates. Digitronics Corporation.

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CHOPPER. A new Millivac type DCM-99K-1 DC modulator is a single pole double throw chopper, which has less than 5 microvolts DC offset and drifts less than 2 microvolts over a long period of time, according to the manufacturer. Millivac Instruments, Division of Cohu Electronics, Inc.

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